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A

TREATISE ON NAVIGATION

AND

NAUTICAL ASTRONOMY,

ADAPTED TO PRACTICE, AND TO THE PURPOSES OF ELEMENTARY INSTRUCTION;

WITH

AN EXTENSIVE SERIES OF EXAMPLES FOR EXERCISE, AND ALL THE TABLES REQUISITE FOR NAUTICAL COMPUTATIONS.

THIRD EDITION,

WITH RULES AND EXAMPLES ADAPTED TO THE NAUTICAL ALMANAC IN ITS NEW AND IMPROVED FORM.

By EDWARD RIDDLE, F.R.A.S.,

MASTER OF THE MATHEMATICAL SCHOOL, ROYAL HOSPITAL, GREENWICH.

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TO

THE RIGHT HONOURABLE

GILBERT, EARL OF MINTO, G.C.B.;

REAR-ADMIRAL SIR CHARLES ADAM, K.C.B.;

REAR-ADMIRAL SIR W. PARKER, C.B.;

THE HONOURABLE GEORGE ELLIOT, C.B.,
CAPTAIN R.N.;

SIR E. T. TROWBRIDGE, BART.,
CAPTAIN R.N.;

AND

THE RIGHT HONOURABLE ARCHIBALD, LORD DALMENY,

THE LORDS COMMISSIONERS FOR EXECUTING THE OFFICE OF LORD HIGH ADMIRAL OF THE UNITED KINGDOM OF GREAT BRITAIN AND IRELAND,

THIS

NEW AND IMPROVED EDITION OF A WORK DESIGNED TO IMPART TO THE PROFESSIONAL EDUCATION OF BRITISH SEAMEN A MORE SCIENTIFIC CHARACTER THAN IT HAS HITHERTO GENERALLY ATTAINED,

IS,

WITH THEIR LORDSHIPS' PERMISSION,

RESPECTFULLY INSCRIBED, BY

THE AUTHOR.

PREFACE.

In the work of which a third edition is now offered to the public, it has been attempted to furnish, in a moderate compass, a mathematical course adapted at once to the instruction of youth destined for the sea service—to the everyday wants of the practical mariner,—and to the more extended views of those who aspire not only to an acquaintance with Navigation as an *art*, but to a knowledge of its principles as a branch of science. Few persons have been extensively employed in teaching Navigation who have not felt the want of some such book. The other works in common use among British seamen are almost exclusively devoted to practice; and the student desirous of other and higher information than they afford, is obliged to have recourse to a variety of works which, besides being expensive, are often little adapted to the state of his previous attainments.

To understand the principles of Navigation and the formulæ for computation in Nautical Astronomy, considerable preparatory knowledge of the elementary branches of mathematical science is indispensable; and it is perhaps the leading characteristic of the following work, that, while it contains all the tables and rules for computation necessary for the practical seaman, it contains also the investigations of the rules, and the preparatory mathematical information necessary for understanding the investigations.

The introductory article on the principles of Algebra is intended merely to enable the student to read, without difficulty, the analytical investigations in Plane and Spherical Trigonometry; and while the treatises on the other elementary branches of science will be found sufficient to serve the purpose for which they are chiefly intended, it is hoped that they may also tend to produce that taste for demonstrative science which is one of the most valuable effects of mathematical instruction.

The most useful trigonometrical formulæ are written out in words, in the form of practical rules; and the whole of the work has been so arranged, that the theoretical and the practical parts may be taught either separately or jointly.

The principles of Navigation are explained at considerable length, and their application shown in the solution of a variety of problems, in plane, parallel, middle latitude, and Mercator's sailing, in keeping a sea journal, and the construction of charts.

An investigation is given of the principles of the quadrant and other reflecting instruments for nautical observations, accompanied with instructions for adjusting them.

The practical rules for the solution of the most useful problems in Nautical Astronomy will, it is hoped, be found simple and unambiguous. The method of finding the latitude from double altitudes will, the author trusts, contribute to bring that problem into general use among practical seamen.

The practical rules and tables for clearing the lunar distance from the effects of parallax and refraction, are deduced from formulæ which were first investigated by J. de Mendoza Rios;—a short trigonometrical process, in which the minute corrections which are neglected in ordinary practice may be introduced, has been added.

It having been found that occultations of stars by the moon can easily be observed at sea, a new and simple rule is given for computing the longitude from these observations.

The method here given for finding the longitude from the observed difference between the intervals of transit of the moon

and a fixed star, may, perhaps, claim the attention of practical astronomers in general, as well as of the scientific individuals engaged, under government, in extensive nautical and geodetic surveys. This, which is now generally considered as the best of all astronomical methods of finding *differences* of longitude, on land, is here reduced either to a simple proportion, or *to the adding together of two logarithms.*

The investigations of the practical rules will present no difficulty to those who understand the theory of Plane and Spherical Trigonometry, as given in the preceding parts of the work; and the concluding Miscellaneous Nautical Problems will afford sufficient variety to guide the student in solving by spherics any useful problem that can arise in practice.

From the care which has been bestowed upon the Tables,—it is believed that few, if any, errors of the least practical importance will be found in them. With respect to Tables, the work has one advantage which in schools will be found of considerable importance. It contains every Table requisite in solving the different examples, the parts of the *Nautical Almanac* being given for the time to which the examples are fitted which require its aid. Another advantage, which the work possesses in this respect, is of not less importance in practice. The Tables of the sun's declination, right ascension, and the equation of time, with the auxiliary Table for reducing them to subsequent years, are sufficient to enable the mariner to find his latitude, and *his longitude by a chronometer,* with sufficient exactness, *at sea,* for nearly sixty years to come, without the aid of the Nautical Almanac.

A work from which any branch of science is to be taught should abound with practical examples; and the following work will, in that respect, be found to answer its object. The examples requiring numerical calculation have, in this edition, been carefully revised.

Grateful for the patronage which his work has received, as evinced by the sale of two very large editions, the author has

endeavoured to make the present edition still more worthy of public support; and *he has adapted it to the Nautical Almanac in the entirely altered and greatly improved form in which, by order of the* LORDS COMMISSIONERS OF THE ADMIRALTY, *it has appeared since the year* 1834.

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ELEMENTARY PRINCIPLES

OF

ALGEBRAICAL CALCULATION.

When quantities are considered algebraically, they are represented by the letters of the alphabet; the leading letters a, b, c, &c. usually representing such quantities as are conceived to be given or known, and the final letters w, x, y, &c. such as are required or unknown.

To abridge analytical expressions, or to indicate the performance of certain operations, several characters are employed, of which the following are the chief: viz.

$+$ named plus,	signifies addition.
$-$ ..... minus,	..... subtraction,
$\mathcal{S}$ ..... difference,	..... the difference of two quantities when it is not known which is the greater.
$\times$ ..... into,	..... multiplication.
$\div$ ..... by,	..... division.
$=$ ..... equal,	denotes the equality of the quantities between which it is placed; and quantities so connected are said to form an Equation.

$:$, $::$, $:$ are used to denote proportion; and a simple dot between two quantities denotes that they are to be multiplied.

——— drawn over, or ( ) inclosing several quantities, denotes that altogether they are to be considered as one quantity.

$\surd$ called the root, or *radical mark*, when by itself, denotes the square root; $\sqrt[3]{}$ denotes the cube root; and, n representing any number whatever, $\sqrt[n]{}$ denotes the n^{th} root.

The second power, or the square of any quantity, as 5, or a, is represented by 5×5, or 5^2; $a\times a$, $a\,.\,a$, aa, or a^2; the third power, or the cube, by $5\times5\times5$ or 5^3; $a\times a\times a$, $a\,.\,a\,.\,a$., aaa, or a^3, &c., and the numbers 2, 3, &c. are called the indices or exponents of the respective powers.

The roots of quantities are also often represented by fractional indices; thus, $7^{\frac{1}{2}}$ means the square root of 7; $a^{\frac{1}{3}}$ the cube root of a; $b^{\frac{1}{4}}$ the fourth root of b; $c^{\frac{3}{5}}$ the fifth root of the cube of c, &c.

Quantities with the sign + prefixed, are called additive, positive, or affirmative quantities, in contradistinction to those which are preceded by the sign −, and which are called subtractive or negative quantities. When no sign is prefixed to a quantity, + is understood. Thus 4 means + 4, and c means + c.

A number prefixed to a letter is called the numeral coefficient of that letter, and it denotes that the quantity which the letter represents is to be taken as many times as there are units in the numeral coefficient.

Hence, if a represent the greater, and b the less of two quantities, $a + b$ will represent their sum, $a - b$ their difference, $a \times b$, $a \,.\, b$, or ab, their product, and $a \div b$, or $\frac{a}{b}$ the quotient of a divided by b.

$\overline{a+b} \,.\, \overline{c \wr e}$, or $(a + b) \,.\, (c \wr e)$ denotes that the sum of a and b is to be multiplied by the difference of c and e. $a - b = \sqrt{c} + \overline{d - e}$ denotes that the difference of a and b is equal to the square root of c added to the difference of d and e. $\overline{a + b} \div \overline{a - b}$, or $\frac{a+b}{a-b}$, denotes that the sum of a and b is to be divided by their difference. $3\,a$ denotes that the quantity a is to be taken 3 times; $5\,bc$ denotes that the product of b and c is to be taken 5 times; and $4 \,.\, \overline{a - b}$ denotes that the difference of a and b is to be taken 4 times.

OF ADDITION.

5 added to 3 times 5 is 4 times 5; 7 added to twice 7 is 3 times 7; and, whatever a may represent, a added to 3 times a is 4 times a. 4 times the product of a and b added to 3 times the product of a and b, is 7 times the product of a and b. The difference of b and c added to twice that difference, is three times the same difference.

Hence $5a + 3a = 8a$. $7bc + 11bc = 18bc$, &c.

Again, if 4 and 7 are both to be subtracted from any quantity, the result will be the same if 11, or their sum, be subtracted from that quantity; and if 3 times a, and 5 times a, be both to be subtracted from any quantity, it will be equivalent to subtracting their sum, or 8 times a, from the same quantity.

Hence $-3a$ added to $-4a$ is $-7a$; $-2bc$ added to $-7bc$ is $-9bc$, &c.

We may therefore conclude, generally, that like quantities with like signs are added together by prefixing the sum of their numeral coefficients, with the common sign, to the literal part.

But when quantities of different kinds are to be joined—as a yard of cloth and a pound of iron, their sum will neither be 2 yards of

cloth, nor 2 pounds of iron, but a yard of cloth and a pound of iron; and this method of expressing their sum admits of no abbreviation. Also, when quantities to be collected together are of the same kind but of different denominations, their sum is taken in the same way, by an enumeration of the parts which compose the whole. Thus, if 2 lines of a certain length were required to be added to 3 lines of a different length, the sum would not be 5 times a line of either of the lengths, but $2\frac{3}{5}$ times the length of the one, added to 3 times the length of the other.

Or the sum of two different quantities, a and b, is represented by $a + b$, not by $2a$ or $2b$. $3bc$ added to $7c$ is $3bc + 7c$, &c.

Hence the sum of unlike quantities is expressed by the quantities themselves, with their proper signs and coefficients.

Again, if 6 is to be added to any quantity, and 2 subtracted, the same result will be produced if 4, or the difference of 6 and 2, be added to that quantity. If 9 is to be subtracted from any quantity, and 3 added to it, this will be equivalent to subtracting 6, or the difference of 9 and 3, from the same quantity.

Or the sum of $+ 6$ and $- 2$ is $+ 4$; the sum of $- 9$ and $+ 3$ is $- 6$; the sum of $- 3a$ and $+ 8a$ is $+ 5a$; the sum of $+ 17\ bc$ and $- 10\ bc$ is $7\ bc$; the sum of $8\frac{a}{b}$ and $-13\frac{a}{b}$ is $-5\frac{a}{b}$.

Hence, like quantities with unlike signs are added together by prefixing to the literal part the difference of the coefficients, with the sign belonging to the greater one.

And where there are several quantities to be collected together, some of which are alike, and others unlike, the sum will be obtained by adding together the like quantities and the unlike ones separately.

Thus, if $a + b$ were to be added to $a + c$, the sum would be $2a + b + c$.

Finally, as 8 times a and 4 times a are equal to 12 times a, or to $\overline{8 + 4}$ times a; and $6b + b$ is equal to $\overline{6 + 1}$ times b, or to 7 times b; we have, generally, $ab + cb + db = b \cdot \overline{a + c + d}$.

Examples in Addition.

1. What is the sum of a, $2a$, $5a$, and $3a$? Answer, $11a$.
2. What is the sum of $2ab$, $4ab$, and $11ab$? Answer, $17ab$.
3. What is the sum of $15\frac{a}{b}$ and $6\frac{a}{b}$? Answer, $21\frac{a}{b}$.
4. What is the sum of 76, 36, and -46? Answer, 66
5. What is the sum of $12bcd$, $3bcd$, and $-bcd$? Answer, $14bcd$.
6. What is the sum of $a + b$ and $a - b$? Answer, $2a$.
7. What is the sum of $a^2 + 2ab + b^2$ and $a^2 - 2ab + b^2$? Answer, $2a^2 + 2b^2$.

OF SUBTRACTION.

8 taken from 6 times 8 leaves 5 times 8; twice 8 taken from 9 times 8 leaves 7 times 8; and, whatever a may represent, 3 times a taken from 13 times a leaves 10 times a; 7 times the sum of a and b taken from 9 times the sum of a and b leaves twice the sum of a and b.

Hence $12\,a - a = 11\,a$, $15\,a\,b - 7\,a\,b = 8\,a\,b$, &c.

Again, if the difference between 4 and 7 were required to be taken from 12; if 7 were taken away, the remainder would be 5: but in deducting 7 too much would be taken away by 4; if, therefore, to the remainder 5, the number 4 were added, the sum 9 would be the required result, or $12 - \overline{7 - 4} = 12 - 7 + 4 = 9$. If from $a + b$ it were required to deduct $\overline{d - c}$; $a + b - d$ would be less than the true remainder by c; for, in subtracting d from $a + b$, too much by c had been taken away.

If, therefore, c were added to $a + b - d$, the sum $a + b - d + c$ would be the required difference of the two given quantities.

Hence, the subtraction of algebraical quantities is performed by changing the signs of all the terms in the quantity to be subtracted, and adding the terms with the signs so changed to the quantity from which the subtraction is to be made

Examples in Subtraction.

1. From $17\,a$ take $3\,a$. Answer, $14\,a$.
2. What is the difference between $8\,a\,b$ and $3\,a\,b$? Answer, $5\,a\,b$.
3. What is the difference between $15\,b + c$ and $6\,b - 3\,c$? Answer, $9\,b + 4\,c$.
4. What is the difference between $4\,a\,b + c$ and $a\,b - 7\,c$? Answer, $3\,a\,b + 8\,c$.
5. From $a + b$ take $a - b$. Answer, $2\,b$.
6. From $a^2 + 2\,a\,b + b^2$ take $a^2 - 2\,a\,b + b^2$. Answer, $4\,a\,b$.

OF MULTIPLICATION.

4 multiplied by 6 denotes that 4 is to be taken 6 times, or that 6 fours are to be added together, and the sum of these 6 fours, or the product of 4 by 6 is represented by 6×4 or 24. $7\,a$ multiplied by 3 denotes that $7\,a$ is to be taken 3 times, and the product is represented by $7\,a \times 3$, or $21\,a$. a multiplied by 5 denotes that a is to be taken 5 times; and the product is represented by $5\,a$. a multiplied by b denotes that a is to be taken as often as there are units in b, and the product is represented by $a\,b$; and, in like manner, if c were multiplied by b, the product would be represented by $b\,c$; and the product of a and b, added to the product of c and b, would therefore be represented by $a\,b + c\,b$, or by $\overline{a + c}\,.\,b$.

Now, if the sum of a and c, or $a + c$, were to be multiplied by b, the product would contain as many times a and as many times c as there are units in b; or $a + c$ multiplied by b would be represented, as above, by $a\,b + c\,b$, or by $\overline{a + c}\,.\,b$.

Again, suppose a to be the greater, and c the less of two quantities, and let the difference of a and c be multiplied by b; for every time that a is taken c must be subtracted; and therefore the product will be represented by as many times a as there are units in b, *diminished* by as many times c as there are units in b, or $a\,b - c\,b$ will represent the required product.

Let now $a + c$ be multiplied by $b - d$. If $a + c$ were multiplied by b alone, the product, as we have already seen, would be $a\,b + c\,b$. But in multiplying by b we have multiplied by a quantity which is too great by d, for the multiplier $b - d$ is only the excess of b above d; therefore, from the product of $\overline{a + c}$ by b, we have to deduct as many times $a + c$ as there are units in d, or we have to subtract $a\,d + c\,d$ from $a\,b + c\,b$, and the remainder $a\,b + c\,b - a\,d - c\,d$, is the required product.

Finally, let $\overline{a - c}$ be multiplied by $b - d$. This signifies that $a - c$ is to be taken as often as there are units in the difference of b and d; or, if $a - c$ be multiplied by b, as many times $a - c$ must be deducted from the product as there are units in d; or, from the product of $a - c$ by b, the product of $a - c$ by d must be subtracted. Now, the product of $a - c$ by b is $a\,b - c\,b$, and the product of $a - c$ by d is $a\,d - c\,d$. And $\overline{a\,b - c\,b} - \overline{a\,d - c\,d} = ab - c\,b - a\,d + c\,d$ is the required product.

We hence deduce the following rule for the multiplication of algebraical quantities.

Multiply every term of the quantity to be multiplied by each term separately of that by which the multiplication is to be made; observing, when the signs of the terms multiplied together are alike, to make the sign of the product $+$; but $-$ when the signs of the terms are unlike; and the sum of the several products will be the total product required.

Note.—As 5^2 signifies 5×5, and 5^4 signifies $5 \times 5 \times 5 \times 5$; $5^2 \times 5^4$ will be the same as $\overline{5 \times 5} \times \overline{5 \times 5 \times 5 \times 5}$, or 5^6; and, in the same way, $a^3 \times a^4 = a\,.\,a\,.\,a \times a\,.\,a\,.\,a\,.\,a\,. = a^7$; therefore, different powers of the same quantity are multiplied by the addition of their indices.

Examples in Multiplication.

1. Multiply $3\,a$ by 11. Answer, $33\,a$.
2. Multiply a by a. Answer, a^2.
3. Multiply $\overline{a + b}$ by $\overline{a - b}$. Answer, $a^2 - b^2$.
4. Multiply $\overline{a - b}$ by $\overline{a - b}$, or find the square of $a - b$. Answer, $a^2 - 2\,a\,b + b^2$.

5. Multiply $\overline{a + b}$ by $\overline{a + b}$, or find the square of $a + b$. Answer, $a^2 + 2ab + b^2$.

6. Multiply a^3 by a^2. Answer, a^5.

7. Multiply $5ab$ by $7a$. Answer, $35a^2b$.

8. Multiply $5a + b$ by $7a$. Answer, $35a^2 + 7ab$.

9. Multiply $\overline{a + b}$ by a. Answer, $a^2 + ab$.

OF DIVISION.

3 times 9 divided by 3 gives 9 for the quotient; and 3 times 9 divided by 9 gives 3 for the quotient. In like manner, a times b, or ab, divided by b, gives a for the quotient; and ab divided by a gives b for the quotient.

Again, the quotient of 3 divided by 7 is represented fractionally by $\frac{3}{7}$; 12 divided by 16 is represented fractionally by $\frac{12}{16}$, or as 12 and 16 have a common divisor 4, the quotient $\frac{12}{16}$ in its lowest terms will be $\frac{3}{4}$. In like manner, ma divided by mb is represented by $\frac{ma}{mb}$, or by the equivalent fraction $\frac{a}{b}$.

Further, $12 + 8$, divided by 16, is expressed by $\frac{12 + 8}{16}$, or $\frac{3 + 2}{4}$, or $\frac{5}{4}$, or $1\frac{1}{4}$; and, in the same way, $\frac{12a + 8a}{16}$ is expressed by $\frac{3a + 2a}{4}$, or $\frac{5a}{4}$, or $1\frac{1}{4}a$, or $\overline{1 + \frac{1}{4}}a$, or $a + \frac{a}{4}$.

Again, for the signs, $+a \times +b$ is $+ab$, therefore $\frac{+ab}{+a}$ is $+b$; $+a \times -b$ is $-ab$, therefore $\frac{-ab}{-b}$ is $+a$, and $\frac{-ab}{+a}$ is $-b$. Therefore, in dividing, it is to be observed, that like signs in the factors give $+$ in the quotient, and unlike signs in the factors give $-$ in the quotient.

We have hence the following general rule for division:—Place the dividend over the divisor in the form of a fraction, and this fraction will be the value of the quotient. If either the whole numerator and denominator, or each of their terms, have a common divisor, divide by that divisor, and the result will be the quotient in simpler terms.

As 7^3 divided by 7 is equivalent to $\frac{7 \times 7 \times 7}{7}$, or to 7×7, or to 7^2; and a^6 divided by a^4 is equivalent to $\frac{a.a.a.a.a.a}{a.a.a.a}$, or to $a.a$, or to a^2; the division of different powers of the same quantity is effected by subtracting the index of the divisor from that of the dividend.

Examples in Division.

1. Divide $6\,a$ by 2. Answer, $3\,a$.
2. Divide $7\,a\,b$ by a. Answer, $7\,b$.
3. Divide $a^2 + a\,b$ by b. Answer, $\frac{a^2}{b} + a$.
4. Divide $a^2 - b^2$ by $a - b$. Answer, $a + b$.
5. Divide $a^2 + 2\,a\,b + b^2$ by $a + b$. Answer, $a + b$.
6. Divide $4\,a\,b + 6\,a\,c$ by $2\,a\,d$. Answer, $\frac{2\,b + 3\,c}{d}$.

OF FRACTIONS.

$\frac{3}{3} = 1$, and $\frac{4}{4} = 1$; or, generally, $\frac{a}{a} = 1, \frac{a\,b\,c}{a\,b\,c} = 1$; that is, any fractional expression, whose numerator and denominator are equal, is equal to 1.

$$\frac{2}{9} + \frac{5}{9} = \frac{7}{9}, \frac{3}{8} + \frac{10}{8} = \frac{13}{8}, \text{ or } \frac{a}{b} + \frac{c}{b} = \frac{a+c}{b};$$

$$\frac{7}{5} - \frac{3}{5} = \frac{4}{5}, \text{ or } \frac{a}{b} - \frac{c}{b} = \frac{a-c}{b}; \frac{a+b}{2} + \frac{a-b}{2} = \frac{2\,a}{2} = a.$$

Fractions having a common denominator are therefore added by placing the sum of their numerators; and subtracted, by placing the difference of their numerators over the common denominator.

$$\frac{7}{8} + \frac{2}{9} = \frac{7 \times 9}{8 \times 9} + \frac{2 \times 8}{9 \times 8} = \frac{7 \times 9 + 2 \times 8}{9 \times 8}; \text{ or generally } \frac{a}{b} + \frac{c}{d} = \frac{a\,d + b\,c}{b\,d}, \text{ and } \frac{7}{8} - \frac{2}{9} = \frac{7 \times 9 - 2 \times 8}{9 \times 8}; \frac{a}{b} - \frac{c}{d} = \frac{a\,d - b\,c}{b\,d}; \frac{a+b}{2} - \frac{a-b}{2} = \frac{2\,b}{2} = b.$$

Hence, when the fractions to be added, or subtracted, are of different denominators, they are reduced, as in common vulgar fractions, to equivalent fractions, having a common denominator; and then the sum or the difference of their numerators, so reduced, is placed over the common denominator, for the required sum or difference of the fractions.

Algebraic fractions are, therefore, reduced to a common denominator, added and subtracted exactly in the same manner as common vulgar fractions are.

Examples in Addition and Subtraction of Fractions.

1. Add $\frac{a}{6}$ to $\frac{b}{6}$. Answer, $\frac{a+b}{6}$.
2. Add $\frac{a}{6}$ to $\frac{c}{7}$. Answer, $\frac{7\,a + 6\,c}{42}$.

3. Add $\frac{2a}{3}$ to $\frac{8}{c}$. Answer, $\frac{2ac+24}{3c}$.

4. Add $\frac{a+b}{a-b}$ to $\frac{a-b}{a+b}$. Answer, $\frac{2a^2+2b^2}{a^2-b^2}$.

5. Add 1 to $\frac{b^2+c^2-a^2}{2bc}$. Answer, $\frac{2bc+b^2+c^2-a^2}{2bc}$, or $\frac{\overline{b+c}^2-a^2}{2bc}$.

6. From $\frac{a^2}{b+c}$ subtract $\frac{a^2-1}{b+c}$. Answer, $\frac{1}{b+c}$.

7. From $\frac{a+b}{a-b}$ take $\frac{a-b}{a+b}$. Answer, $\frac{4ab}{a^2-b^2}$.

8. From 1 take $\frac{b^2+c^2-a^2}{2bc}$. Answer, $\frac{2bc-b^2-c^2+a^2}{2bc}$, or $\frac{a^2-\overline{b-c}^2}{2bc}$.

$\frac{6}{53}$ multiplied by 7 is $\frac{42}{53}$, and $\frac{6}{53}$ divided by 7 is $\frac{6}{371}$, or $\frac{a}{b} \times c = \frac{ac}{b}$, and $\frac{a}{b} \div c = \frac{a}{bc}$.

Again, $\frac{3}{5} \times \frac{2}{7} = \frac{6}{35}$, and $\frac{3}{5} \div \frac{2}{7} = \frac{3}{5} \times \frac{7}{2} = \frac{21}{10}$; or $\frac{a}{b} \times \frac{c}{d} = \frac{ac}{bd}$; and $\frac{a}{b} \div \frac{c}{d} = \frac{ad}{bc}$.

The multiplication and division of algebraic fractions are therefore performed in the same manner as in vulgar fractions: *multiplication* being effected by taking the product of the numerators and denominators respectively, for the numerators and denominators of the fractional product; and *division*, by taking, in the same manner, the product of the dividend and the reciprocal of the divisor.

EXAMPLES IN MULTIPLICATION AND DIVISION OF FRACTIONS.

1. Multiply $\frac{a}{b}$ by a. Answer, $\frac{a^2}{b}$.

2. Multiply $\frac{6bc}{41a}$ by $\frac{2a}{bc}$. Answer, $\frac{12}{41}$.

3. Multiply $\frac{7b}{11}$ by $\frac{11}{7b}$. Answer, 1.

4. Multiply $\frac{a+b}{a^2-b}$ by $\frac{a-b}{a^2+b^2}$. Answer, $\frac{a^2-b^2}{a^4+a^2b^2-a^2b-b^3}$.

5. Divide $\frac{ab+nabcd}{ab-nabcd}$ by ab. Answer, $\frac{1+ncd}{ab-nabcd}$.

6. Divide $\frac{a}{b}$ by $\frac{c}{b+a}$. Answer, $\frac{ab+a^2}{bc}$.

7. Divide $\frac{6}{7}$ by $\frac{a}{4}$. Answer, $\frac{24}{7a}$.

8. Divide $\frac{\overline{a+b}^2 - \overline{a-b}^2}{\overline{a+b}^2 + \overline{a-b}^2}$ by $\frac{2ab}{c}$. Answer, $\frac{c}{a^2+b^2}$.

OF THE TRANSPOSITION OF THE TERMS OF EQUATIONS.

If $9+4=13$, then $9=13-4$; and if $9=13-4$, then $9+4=13$.

If $8+7=11+4$, then $8+7-4=11$, and $8-4=11-7$; or, if $a+b=c$, then $a=c-b$; and if $a=c-b$, then $c=b+a$.

Whence a term, or any number of terms, may be transposed from one side of an equation to the other, without destroying the equality, by changing the sign of each term so transposed.

Again, if $9+4=13$, then $9+4-13=0$; and if $9+4-13=0$, $9+4=13$, or, generally, if $a+b=c$, then $a+b-c=0$; and if $a+b-c=0$, then $a+b=c$; if $a-c+d=e$, then $0=e-a+c-d$, or $a-c+d-e=0$.

Hence, if all the terms on one side of an equation be transposed with their signs changed, the resulting expression will be equal to 0.

If $\frac{8}{4}=2$, then $8=2\times 4$, or if $\frac{a}{b}=c$, then $a=bc$; if $7\times 9=63$, then $7=\frac{63}{9}$, or if $ab=c$, then $a=\frac{c}{b}$; if $\frac{7}{2}=10-6\frac{1}{2}$, then $7=20-13$; if $\frac{a}{b}=c+d-e$, then $a=cb+db-eb$; if $6\times 8=64-16$, then $6=\frac{64}{8}-\frac{16}{8}$; or if $ab=c+d-e$, then $a=\frac{c}{b}+\frac{d}{b}-\frac{e}{b}$.

Hence, if a term of an equation be multiplied by any number, the multiplier may be omitted, if all the other terms of the equation be divided by that number; and, conversely, if a term of an equation be divided by any number, the divisor may be omitted, if all the other terms of the equation be multiplied by it.

If $4^2=16$, then $4=\sqrt{16}$; or if $4^2=12+4$, then $4=\sqrt{12+4}$; or if $a^2=b$, then $a=\sqrt{b}$; or if $a^2=b+c-d$, then $a=\sqrt{b+c-d}$; if $\sqrt{a}=b$, then $a=b^2$; if $\sqrt{a}=b-c$, then $a=\overline{b-c}^2$

Hence if a power of any required quantity be given, the quantity itself will be obtained by extracting the corresponding root of the given quantity; and if a root of any quantity be given, that quantity will be the corresponding power of the given quantity.

EXAMPLES.

1. Given $x + 4 = 18$ to find x. Answer, $x = 14$.
2. Given $x - 7 = 12 + 3$ to find x. Answer, $x = 22$.
3. Given $y + a = 4 - b$ to find y. Answer, $y = 4 - b - a$.
4. Given $4 + 7 - 9 = x - 8$ to find x. Answer, $x = 10$.
5. Given $8x = 24$ to find x. Answer, $x = 3$.
6. Given $7x + 3 = 31$ to find x. Answer, $x = 4$.
7. Given $\frac{x}{8} = 3$ to find x. Answer, $x = 24$.
8. Given $\frac{x}{7} + 4 = 11 - 2$ to find x. Answer, $x = 35$.
9. Given $x^2 + a = b - c$ to find x. Answer, $x = \sqrt{b - c - a}$.
10. Given $2bcx = b^2 + c^2 - a^2$ to find x. Ans. $x = \frac{b^2 + c^2 - a^2}{2bc}$.
11. Given $x^2 = 14 + 4 - 3$. Answer, $x = \sqrt{15}$.

OF LOGARITHMS.

LOGARITHMS are a series of numbers contrived to lessen the labour attending many troublesome calculations; the operation of multiplication being effected by the addition, and that of division by the subtraction of logarithms. The raising of powers is effected by multiplying the logarithms by the index of the power; and the extraction of roots, by dividing the logarithm by the index of the root.

Logarithms may be considered as the exponents of the powers of a certain number, called the root or radix of the system; or they may be considered as an arithmetical series, indicating the places of the numbers in a corresponding geometrical one.

The common system of logarithms, or that which is most used, and most useful in common calculations, has 10 for its root; and the logarithm of any number in that system, is that power of 10 which is equal to the given number.

Thus 10^1 is 10, 10^2 is 100, 10^3 is 1000; the log of 10 therefore is 1, that of 100 is 2, and that of 1000 is 3, &c.

Now 10^3, 10^2, 10, 1, $\frac{1}{10}$, $\frac{1}{100}$, &c. form a continually decreasing geometrical series; their logarithms therefore form a continually decreasing arithmetical series.

Nos . 1000 . 100 . 10 . 1 . ·1 . ·01 &c.
Logs . 3 . 2 . 1 . 0 . −1 . − 2 &c.

Hence the log of 1 is 0, and the logs of all numbers less than 1 have their indices negative; the log of every number between 1 and 10 is between 0 and 1; the log of every number between 10 and 100 is between 1 and 2; the log of every number between 100 and 1000 is between 2 and 3, &c. The numbers 1, 2, 3, &c., called the

indices of the logarithms, are therefore always less by one than the digits contained in the integral part of the number whose logarithm is taken.

From what has been said, it is evident that the logs of 10 and all its integral powers will be whole numbers; but to determine from these what the logarithms of other numbers are, is a task attended with a good deal of trouble; and as our object is rather to point out the principal properties of logarithms, and to explain their practical uses, than to give a view of the many refined artifices which have been employed in computing them, we shall merely show by one example how the logarithm of any number may be determined; and that example may suffice to convince us how much we are indebted to the industry and the skill of those persons, whose labours have furnished us with the extensive tables which we now possess.

Example.

Let it be required to find the logarithm of 9.

Here the proposed number lies between 1 and 10.

First, then, the log of 10 is 1, and the log of 1 is 0; therefore $\overline{1 + 0} \div 2 = \frac{1}{2} = \cdot 5$ is the arithmetical mean, and $\sqrt{10 \times 1} = \sqrt{10} = 3{\cdot}1622777$ the geometrical mean; hence the log of 3·1622777 is ·5.

Secondly, the log of 10 is 1, and the log of 3·1622777 is ·5; therefore $\overline{1 + \cdot 5} \div 2 = \cdot 75$ is the arithmetical mean, and $\sqrt{10 \times 3{\cdot}1622777} = 5{\cdot}6234132$ is the geometrical mean; hence the log of 5·6234132 is ·75.

Thirdly, the log of 10 is 1, and the log of 5·6234132 is ·75; therefore $\overline{1 + \cdot 75} \div 2 = \cdot 875$ is the arithmetical mean, and $\sqrt{10 \times 5{\cdot}6234132} = 7{\cdot}4989422$ the geometrical mean; hence the log of 7·4989422 is ·875.

Fourthly, the log of 10 is 1, and the log of 7·4989422 is ·875; therefore $\overline{1 + \cdot 875} \div 2 = \cdot 9375$ is the arithmetical mean, and $\sqrt{10 \times 7{\cdot}4989422} = 8{\cdot}6596431$ the geometrical mean; hence the log of 8·6596431 is ·9375.

Fifthly, the log of 10 is 1, and the log of 8·6596431 is ·9375; therefore $\overline{1 + \cdot 9375} \div 2 = \cdot 96875$ is the arithmetical mean, and $\sqrt{10 \times 8{\cdot}6596431} = 9{\cdot}3057204$ the geometrical mean; hence the log of 9·3057204 is ·96875.

Sixthly, the log of 8·6596431 is ·9375, and the log of 9·3057204 is ·96875; therefore $\overline{\cdot 9375 + \cdot 96875} \div 2 = \cdot 953125$ is the arithmetical mean, and $\sqrt{8{\cdot}6596431 \times 9{\cdot}3057204} = 8{\cdot}9768713$ the geometrical mean; hence the log of 8·9768713 is ·953125.

And proceeding in this manner, after 25 extractions, it will be

found that the logarithm of 8·9999998 is ·9542425; which may be taken for the logarithm of 9, as it differs so little from it that it is sufficiently exact for all practical purposes.

And thus were the logarithms of almost all the prime numbers at first computed.

Having found in this manner the logarithms of all prime numbers, which are those that have no divisor; as, 2, 3, 5, 7, 11, &c. the logarithms of all other numbers may easily be found. For, as $3 \times 5 = 15$, the logarithms of 3 and 5 added together will be the logarithm of 15, and as $3^2 = 9$, twice the logarithm of 3 will be the logarithm of 9, &c. And thus may an idea be formed of the method of constructing a table of logarithms.

The logarithms constructed to the radix 10 possess one very important practical advantage; which is, that all numbers consisting of the same figures, whether they be integral, fractional, or mixed, have *the decimal* parts of their logarithms the same.

For, the log of $a \times 10^n$ is equal to n added to the log of a; and the log of $a \div 10^n$ is equal to the log of a diminished by n.

Thus the log of 628 ..... is 2·797960

62·8 or $\frac{628}{10}$ ..... is 1·797960

6·28... $\frac{628}{10^2}$ ..... is 0·797960

·628... $\frac{628}{10^3}$ ..... is −1·797960

·0628... $\frac{628}{10^4}$ ..... is −2·797960

Examples of the Use of Logarithms.

1. Multiply 849 by 76.

	849	log 2·928908
	76	log 1·880814
Product..	64524	log 4·809722

2. Multiply 34 by ·9.

	34	log 1·531479
	·9	log −1·954243
Product..	30·6	log 1·485722

3. Divide 1496 by 1213.

	1496	log 3·174932
	1213	log 3·083861
Quotient..	1·233	log ·091071

4. Divide 732 by ·02.

732	log	2·865411
·02	log	− 2·301030
Quotient..36600	log	4·563481

5. Find a fourth proportional to 567, 913, and 485.

As, to perform the required operation without the aid of logarithms, we must divide the product of 913 and 485 by 567; therefore, to perform it logarithmically, from the sum of the logarithms of 913 and 485, we must deduct the logarithm of 567 for the logarithm of the result.

Thus,

567	log	2·753583
913	log	2·960471
485	log	2·685742
		5·646213
Required fourth proportional..781	log	2·892630

6. Extract the 6th root of 148

148	log	2·170262
		6)2·170262
Required root..2·3	log	·361710

GEOMETRY.

Definitions.

1. Geometry is the science by which we determine the relations between quantities that have extension.

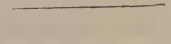
2. A *Point* is that which has position, but no magnitude.

3. A *Line* is length only.

4. A *Surface*, or *Superficies*, is a figure which has length and breadth only.

5. A *Solid* is a figure which has length, breadth, and thickness.

6. A *Right Line*, or *Straight Line*, is one which does not change its direction between its extremities.

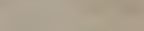


7. A *Crooked Line* is one which changes its direction at intervals.

8. A *Curve Line* is one which continually changes its direction.

9. When a line is not stated to be *crooked*, or *curved*, it is understood to be *straight*.

10. *Parallel Lines* are those which, being in the same plane, will not meet, though produced to any distance.

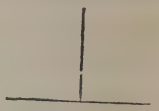


11. *Oblique Lines* are those which will meet if produced.

12. A Line is a *Tangent* to a curve, when the line touches the curve without cutting it, when both are produced.

13. An *Angle* is the inclination of two lines which diverge from the same point.

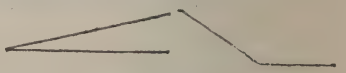
14. A *Perpendicular* is a line meeting another line, so that the angles on each side of it are equal.



15. A *Right Angle* is the angle formed by a perpendicular with the line which it meets.

16. An *Oblique Angle* is one which is formed by the meeting of two lines not at right angles to each other.

17. An *Acute Angle* is less, and an *Obtuse Angle* is greater, than a right angle.

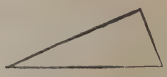


18. A *Plane Surface*, or a *Plane*, is that with which a right line may every way coincide.

19. A *Curve Surface* is that with which a right line will not every way coincide.

20. *Plane Figures* are bounded either by right lines or curves, and they have as many angles as they have sides.

21. A *Triangle* is a figure of three sides.



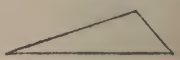
22. An *Equilateral Triangle* is one whose sides are all equal.

23. An *Isosceles Triangle* has only two of its sides equal.

24. A *Scalene Triangle* is one whose sides are all unequal.

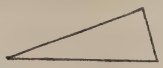
25. A *Right Angled Triangle* has one of its angles a right angle.

26. An *Oblique Angled Triangle* is one whose angles are all oblique.



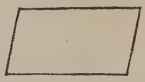
27. An *Obtuse Angled Triangle* has one obtuse angle.

28. An *Acute Angled Triangle* has all its angles acute.

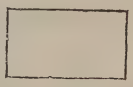


29. A figure of four sides is called a *Quadrilateral*, or a *Quadrangle.*

30. A *Parallelogram* is a quadrilateral having each pair of opposite sides parallel.

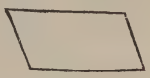


31. A *Rectangle* is a parallelogram having one of its angles a right angle; and it is said to be contained by any two of its adjoining sides.



32. A *Square* is a rectangle having all its sides equal.

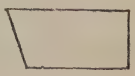
33. A *Rhomboid* is a parallelogram, one of whose angles is oblique.



34. A *Rhombus* is a rhomboid whose sides are all equal.

35. A *Trapezium* is a quadrilateral which has not its opposite sides parallel.

36. A *Trapezoid* is a quadrilateral having only one pair of opposite sides parallel.



37. A *Diagonal* is a line joining the opposite angular points of a quadrilateral.

38. Plane figures of more than four sides receive the general denomination of *Polygons.*

39. A Polygon of five sides is called a *Pentagon;* one of six sides a *Hexagon;* one of seven sides a *Heptagon;* one of eight sides an *Octagon*, &c.

40. A *Regular Polygon* is one which has all its sides equal, and also all its angles equal.

41. An *Irregular Polygon* is one which has not all its sides and all its angles equal.

42. A *Circle* is a plane figure bounded by a curve line, every part of which is equally distant from a a certain point within the figure, called the centre.

43. The curve line which bounds the circle is called the *Circumference. Note*, the *Circumference* is sometimes called the *Circle.*

44. The *Radius* of a circle is a line drawn from the centre to the Circumference.

45. The *Diameter* of a circle is a line drawn through the centre and terminating on both sides at the circumference.

46. An *Arc* of a circle is any part of the circumference.

47. A *Chord* is the straight line joining the extremities of an arc.

48. A *Segment* is a part of a circle bounded by an arc and its chord.

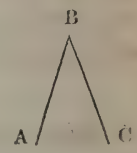
49. A *Semicircle* is a segment cut off by a diameter.

50. A *Sector* is a part of a circle bounded by two radii and their intercepted arc.

51. A *Quadrant* is a sector whose bounding radii are perpendicular to each other.

52. In a right angled triangle, the side opposite the right angle is called the *Hypothenuse*, and the sides including the right angle are called the *Base* and *Perpendicular*, and sometimes *the legs* of the triangle.

53. When an angle is denoted by three letters, one of them is placed at the angular point, and the other two on the lines which include the angle; and *that which stands at the angular point is read in the middle* as A B C, or C B A.

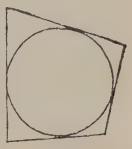


54. An angle in a segment of a circle is contained by two lines drawn from any point in the arc of the segment to the extremities of the same arc.

55. An angle *on* a segment, or *on* an arc, is contained by two lines drawn from the extremities of the arc to any point in the opposite part of the circumference.

56. An angle *at the circumference* of a circle is one whose angular point is in the circumference; and an angle *at the centre*, is one whose angular point is at the centre.

57. A rectilineal figure is inscribed in a circle, or the circle circumscribes the rectilineal figure, when all the angular points of the figure are in the circumference of the circle.



58. A rectilineal figure circumscribes a circle, or the circle is inscribed in the rectilineal figure, when each side of the figure touches the circumference of the circle without cutting it.

59. A rectilineal figure is inscribed in another, or the latter circumscribes the former, when all the angular points of the former are placed on the sides of the latter.

60. *Identical Figures* are those which are mutually equal in all their parts.

61. *Similar Figures* are those which have all the angles of the one equal to all the angles of the other, and the corresponding sides about the angles of each figure, proportional.

62. The *Perimeter* of a figure is the sum of all its sides.

63. A *Problem* is an operation proposed to be performed.

64. A *Theorem* is a truth which it is proposed to prove.

65. A *Proposition* is a general term, signifying either a problem or a theorem.

66. A *Lemma* is a preparatory proposition to render what follows more easy.

67. A *Corollary* is an obvious consequence resulting from a preceding proposition.

68. A *Scholium* is an observation, or remark, upon something preceding it.

69. An *Axiom* is a self evident truth.

70. A *Postulate* is a request to admit the *possibility* of performing a certain operation.

AXIOMS.

1. Things which are equal to the same thing, are equal to each other.

2. When equals are added to equals, the wholes are equal.

3. When equals are taken from equals, the remainders are equal.

4. When equals are added to unequals, the wholes are unequal.

5. When equals are taken from unequals, the remainders are unequal.

6. Things which are like multiples of the same, or of equal things, are equal to each other.

7. Things which are like parts of the same, or of equal things, are equal to each other.

8. The whole of any thing is equal to the sum of all its parts.

9. The whole of any thing is greater than a part of it.

10. Magnitudes which coincide with one another, or fill the same space, are identical or mutually equal in all respects.

11. All right angles are equal to one another.

12. If two straight lines are parallel to each other, a line which meets one of them will, if produced, meet the other.

13. If two straight lines intersect each other, they cannot both be parallel to the same straight line.

POSTULATES.

1. Let it be granted that a straight line may be drawn from any one point to any other point.

2. That a straight line may be produced to any length in the same direction.

3. That a circle may be described round any point as a centre, and with any radius.

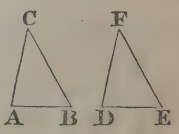
4. That from any point in a given straight line a perpendicular to that line may be drawn.

5. That a right line, or rectilineal angle may be made equal to any given right line, or rectilineal angle, that any right line or rectilineal angle may be bisected; and that through a given point a line may be drawn parallel to any other line.

THEOREMS.

Theorem I.

In any two triangles A B C, D E F, *if two sides* C A, C B, *in the one, be respectively equal to two sides* F D, F E, *in the other, and the angle* C *included by the sides* C A, C B, *in the one, be equal to the angle* F, *included by the equal sides* F D, F E *in the other; then the two triangles are identical, or equal in all respects; and have the angles equal which are opposite to the equal sides.*

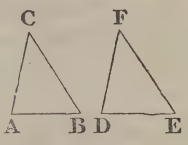


For, conceive the point C to be laid on the point F, and the line C A on the line F D, then, because these lines are equal, the point A will coincide with the point D. And as C A coincides with F D, and the angle C is equal to the angle F, the line C B will fall on the line F E; and, because C B and F E are equal, the point B will coincide with the point E. Therefore as the points A and B

coincide with the points D and E, the line A B will coincide with the line D E. Hence the two triangles are identical, and have all the parts of the one equal to the corresponding parts of the other; namely, the side A B to the side D E, the angle A to the angle D, and the angle B to the angle E. Q. E. D.

Theorem II.

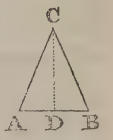
In any two triangles A B C, D E F, *if two angles* A *and* B *in the one be respectively equal to two angles* D *and* E *in the other, and the sides* A B *and* D E *adjacent to these equal angles be also equal, the triangles are identical, or equal in all respects.*



For conceive the point A to be laid on the point D, and the side A B on the side D E, then because these lines are equal, the point B will coincide with the point E. And as A B and D E coincide, and the angle A is equal to the angle D, the side A C will fall on the side D F; and for a like reason B C will fall on E F. Therefore as A C falls on D F, and B C on E F, the point C must coincide with the point F; and consequently the two triangles are identical; having the other two sides A C, B C, equal to the two D F, E F, and the remaining angle C equal to the remaining angle F. Q. E. D.

Theorem III.

In any isosceles triangle A B C, *the angles* A *and* B, *opposite the equal sides,* A C *and* B C, *are equal.*



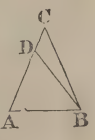
For, conceive the angle C to be bisected by the line C D then as the two triangles A C D and B C D, have A C equal to B C, C D common to both, and the angle A C D equal to the angle B C D, they are identical (Theo. 1), and therefore the angle A is equal to the angle B. Q. E. D.

Cor. 1. The line which bisects the angle included between the equal sides of an isosceles triangle, bisects the third side, and is also perpendicular to it.

Cor. 2. Every equilateral triangle is also an equiangular one.

Theorem IV.

If any triangle A C B, *have two equal angles as* C B A *and* C A B, *the sides* A C *and* B C *opposite those equal angles are also equal to each other.*



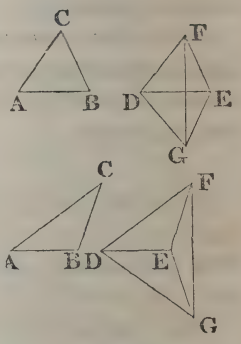
For if A C and B C are not equal, suppose one of them, as A C, to be longer than the other, and let A D be the part of A C which is equal to B C; and join B D. Then, because A D is equal to B C, A B common to both, and the angle D A B equal to the angle C B A; therefore, the triangle A D B is equal to the triangle A B C (Theo. 1), the less to the greater,

which is impossible. Hence A C and B C are not unequal, that is, they are equal. Q. E. D.

Cor. Every equiangular triangle is also an equilateral one.

THEOREM V.

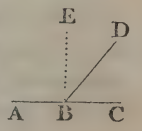
If any two triangles, as A B C, D E F, *have the sides* A C *and* D F, A B *and* D E, *and* B C *and* E F, *respectively equal, the triangles are identical, and have the angles equal which are opposite to the equal sides.*



For, let the point A be laid on the point D, and the line A B on the line D E; then, because these lines are equal, the point B will coincide with the point E. Let the point C fall at G, the points G and F being on opposite sides of the line D E, and let F G be joined. Then as D F and D G are each equal to A C, they are equal to each other, and consequently the angles D F G and D G F are equal (Theo. 3). In the same way E F G and E G F may be shewn to be equal; and consequently the angles D F E and D G E, or A C B, are equal. Hence, as the two sides A C, B C are respectively equal to the two sides D F, F E, and the angle A C B is also equal to the angle D F E, the triangles A B C and D F E are identical (Theo. 1.), and have the angle B A C equal to the angle E D F; and the angle A B C equal to the angle D E F. Q. E. D.

THEOREM VI.

The angles D B A *and* D B C *which one straight line* B D *makes with another,* A C, *on the same side of it, are either two right angles, or together they are equal to two right angles.*



For if D B is perpendicular to A C, then each of the angles D B A and D B C is a right angle. But if B D is not perpendicular to A C, let B E be perpendicular to it, then each of the angles A B E and E B C is a right angle, and A B D exceeds a right angle by E B D, and D B C is less than a right angle by the same angle E B D; the two angles, A B D and D B C, are therefore together equal to two right angles. Q. E. D.

Cor. 1. All the angles that can be made at any point as B, by any number of lines, drawn on the same side of a line A C, are together equal to two right angles.

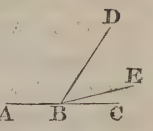
Cor. 2. As all the angles that can be made at the point B, on the other side of the line A C, are together equal to two right angles, all the angles that can be made, in the same plane, about any point, as B, are together equal to four right angles.

Cor. 3. If a straight line revolve in a plane about a point in which one extremity of the line remains, the angles which the successive positions of the revolving line make with each other during a complete revolution, are together equal to four right angles; and the corresponding portions of the circumference of the circle, described by the other extremity of the revolving line, make together the whole circumference. If, therefore, the circumference of a circle be assumed as the measure of four right angles, the arc intercepted between any two radii may be considered as the measure of the angle which these two radii make with each other.

Cor. 4. And hence we may further infer that with the same radius, equal angles have equal measures, that the arc of a semicircle is the measure of two right angles, and the arc of a quadrant, the measure of one right angle.

Theorem VII.

If two lines A B, B C, *on opposite sides of the line* B D, *meet that line in the same point* B, *so as to make the adjacent angles* A B D *and* D B C *together equal to two right angles, these two lines* A B *and* B C *are in the same straight line.*



For if they are not in the same straight line, let A B produced, be in the direction B E. Then the angles A B D and D B E together, are equal to two right angles (Theor. 6.); and as A B D and D B C together are also given equal to two right angles; if the common angle A B D be omitted from each of these equal sums, the remaining angles D B E and D B C must be equal; a part to the whole, which is impossible. The lines A B and B C are therefore not otherwise than in the same straight line, that is they form one straight line. Q. E. D.

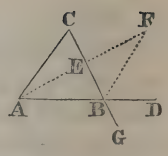
Theorem VIII.

If two straight lines A B, D E, *intersect each other in* C, *any two vertical or opposite angles, as* A C D *and* B C E, *are equal.*

For as A C meets D E in C, the angles A C D and A C E are together equal to two right angles (Theo. 6.); and for a like reason the angles B C E and A C E are equal to two right angles. Hence the angles A C D and A C E together are equal to the angles B C E and A C E together; and by omitting from each sum the common angle A C E, we have the remaining angles A C D and B C E equal to each other. Q. E. D.

Theorem IX.

If any side, as A B, *of a triangle* A B C *be produced, as to* D, *the outward angle* C B D *is greater than either of the inward and opposite angles* A *and* C.

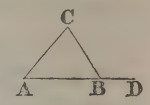


For let B C be bisected in E, join A E, and produce it till E F is equal to A E, and join B F; then because A E is equal to E F, and B E to E C, and the angle A E C to the angle F E B (Theo. 8.), therefore the angle F B E is equal to the angle A C E (Theo. 1.), and consequently the whole angle D B C is greater than the angle C.

In the same way, by producing C B, and bisecting A B, it may be shewn that the angle A B G, which is equal to C B D, is greater than B A C. Q. E. D.

Theorem X.

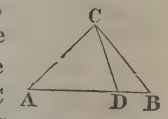
Any two angles, as A B C *and* B C A, *of a triangle* A B C, *are together less than two right angles.*



For let A B be produced to D, then the angles A B C and C B D are together equal to two right angles; but the angle C B D is greater than the angle A C B; consequently the angles A B C and A C B together are less than the two right angles. Q. E. D.

Theorem XI.

In any triangle A B C *if the side* A B *be greater than the side* A C, *the angle* A C B, *opposite the greater side, is greater than the angle* A B C *opposite the less.*

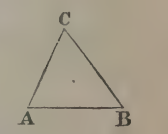


For let A D be the part of A B which is equal to A C, and join D C; then because A C and A D are equal, the angles A C D and A D C are equal (Theo. 3.). But the angle A D C is greater than the angle D B C or A B C (Theo. 9.); whence A C D is also greater than A B C. Much more therefore is the whole angle A C B greater than A B C. Q. E. D.

Cor. In any triangle, the greatest side has the greatest angle opposite to it, and the least side has the least angle opposite to it.

Theorem XII.

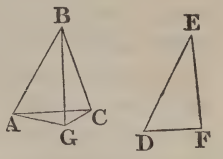
In any triangle A B C, *if one angle, as* A, *be greater than another angle, as* B, *the side* B C, *opposite the greater angle, is greater than the side* A C *opposite the less.*



For if B C is not greater than A C it must be either equal to it or less; B C cannot be equal to A C, for then the angle C A B would be equal to the angle A B C (Theo. 3.), which it is not, by condition; neither can it be less, for then the angle C A B would be less than A B C (Theo. 11.), which it is not, by condition. Hence as B C is neither equal to A C nor less than it, it must be greater. Q. E. D.

Theorem XIII.

If two triangles A B C, D E F, *have two sides* A B, B C, *of the one respectively equal to* D E, E F, *two sides of the other, but the angle* A B C, *included by the two sides of the one, greater than the angle* D E F *included by the corresponding sides of the other; then the side* A C *is greater than the side* D F.



Let A B G be the part of the angle A B C which is equal to D E F, and let B G be equal to E F or B C. Then the triangles A B G, D E F are identical (Theo. 1.), and have the sides A G and D F equal to each other. And as B C and B G are equal, the angles B C G and B G C are equal (Theo. 3.); hence B G C is greater than A C G, and much more is A G C greater than A C G; therefore (Theo. 12.) A C is greater than A G, or than its equal D F. Q. E. D.

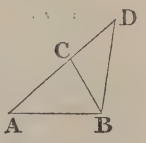
Theorem XIV.

If two triangles A B C, D E F (see the last figure) *have two sides* A B, B C *of the one respectively equal to* D E, E F, *two sides of the other, but the third side* A C *of the one greater than the corresponding side* D F *of the other, then the angle* A B C *is greater than the angle* D E F.

If A B C is not greater than D E F, it must either be equal to it, or less. But if A B C and D E F were equal, then A C and D F would be equal (Theo. 1.), *which they are not;* and if A B C were less than D E F, then A C would be less than D F (Theo. 13.), *which it is not.* Hence, as A B C is neither equal to D E F nor less, it must be greater. Q. E. D.

Theorem XV.

In any triangle A B C, *the sum of any two of its sides, as* A C *and* C B, *is greater than the remaining side* A B.



For let A C be produced till C D is equal to C B, and join D B; then because C D is equal to C B, the angle C D B is equal to the angle C B D (Theo. 3.); therefore the whole angle A B D is greater than the angle C D B or A D B; and consequently (Theo. 12.) the side A D, or the sum of A C and C B, is greater than A B. Q. E D.

Theorem XVI.

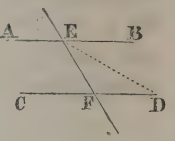
In any triangle A B C, (Fig. Theo. 11.) *the difference of any two of its sides, as* A B *and* A C, *is less than the remaining side* B C.

For let A D be the part of A B which is equal to A C, then D B is the difference of A B and A C; and as A C and B C together are greater than A B (Theo. 15.), or than A D and D B together; if the equal parts A C and A D be taken from each sum, the remainder B C

must be greater than the remainder D B; or D B is less than B C. Q. E. D.

Theorem XVII.

If a line E F *intersect two parallel lines* A B *and* C D, *the alternate angles* B E F *and* C F E *are equal to each other.*

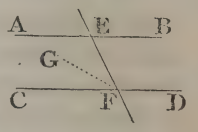


For if they are not equal, one of them must be greater than the other. Suppose B E F to be the greater, and let D E F, a part of B E F, be equal to C F E. Then because E B is parallel to C F, E D which meets E B, will also if produced meet C F in some point as D (Axiom 12). Then because E F C is the outward angle of the triangle F E D, it is greater than the inward and opposite angle F E D (Theo. 9.); but these angles are also by supposition equal, which is impossible. The angles B E F and C F E are therefore not unequal, that is, they are equal to each other. Q. E. D.

Cor. A line which is perpendicular to one of two parallel lines, is also perpendicular to the other.

Theorem XVIII.

If a line E F *meet two other lines* A B *and* C D, *and the alternate angles* B E F *and* E F C *be equal, the lines* A B *and* C D *are parallel.*

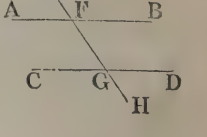


For if C D is not parallel to A B, from F, the point in which E F meets C D, let F G be drawn parallel to A B. Then as the angles B E F and E F C are equal by hypothesis, and the alternate angles B E F and E F G are also equal (Theo. 17.), the angle E F G must be equal to the angle E F C; the less to the greater, which is impossible. Therefore no line passing through F, except C D, is parallel to A B; and consequently C D is parallel to A B. Q. E. D.

Cor. Lines which are perpendicular to the same line are parallel to each other.

Theorem XIX

If two parallel lines A B, C D, *be cut by another line* E H, *in the points* F *and* G, *any outward angle, as* E F A, *is equal to the inward opposite angle* F G C *on the same side of* E H; *and any two inward angles, as* A F G *and* F G C, *on the same side of* E H, *are together equal to two right angles.*



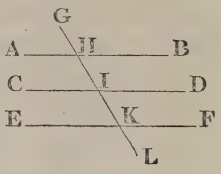
For the angle A F E is equal to B F G (Theo. 8.), which angle is equal to F G C (Theo. 17.); hence the angles A F E and F G C are equal. But A F E and A F G together make two right angles (Theo. 6.); therefore A F G and F G C together are equal to two right angles. Q. E. D.

Cor. 1. If a line meeting two other lines make the outward angle equal to the inward and opposite one, on the same side of the line; or if the two inward angles on the same side of the line be, together, equal to two right angles, these two lines are parallel.

Cor. 2. If a line cut two other lines, and the outward angle be not equal to the inward and opposite one on the same side of the line; or if the two inward angles on the same side of the line are not together equal to two right angles; these two lines are not parallel, and they will therefore meet if produced.

Theorem XX.

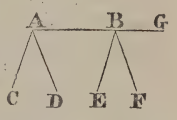
If any two lines, A B *and* C D, *be each parallel to another line* E F; *the lines* A B *and* C D *are parallel to each other.*



For let the line G L cut the lines A B, C D, and E F, in the points H, I, and K. Then the angles G H B and H I D, being each equal to I K F (Theo. 19.), are equal to each other; therefore A B and C D are parallel (Theo. 19. cor. 1.). Q. E. D.

Theorem XXI.

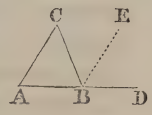
If two lines A C, A D *meeting in a point* A, *be parallel to two other lines* E B, B F, *meeting in another point* B; *the included angles* C A D *and* E B F *are equal to each other.*



For join A B and produce the line to G; then, as the angle C A B is equal to the angle E B G, and the angle D A B to the angle F B G (Theo. 19.); the equal angles B A D and G B F, taken from the equal angles B A C and G B E, leave the remaining angles C A D and E B F equal to each other. Q. E. D.

Theorem XXII.

If any side A B, *of a triangle* A B C, *be produced, the outward angle* C B D, *is equal to both the inward and opposite angles* B A C, *and* A C B, *taken together.*

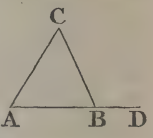


For let B E be a line parallel to A C. Then the angle C is equal to the angle C B E (Theo. 17.); and the angle A to the angle E B D (Theo. 19.); hence the whole angle C B D is equal to the two angles A and C together. Q. E. D.

Cor. The angle C is the difference between the outward angle C B D and the other inward and opposite angle A; and A is the difference between C B D and C.

Theorem XXIII.

The three interior angles of any triangle A B C, *are together equal to two right angles.*



For let A B be produced to D; then the angle C B D is equal to the angles A and C together (Theo. 22.). But the angles C B D and C B A are together equal to two right angles (Theo. 6.); whence the three interior angles A B C, A C B, and B A C are together equal to two right angles. Q. E. D.

Cor. 1. If two angles in one triangle be equal to two angles in another triangle, the remaining angles of those triangles are equal.

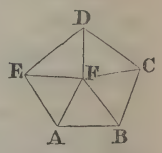
Cor. 2. If one angle in a triangle be equal to an angle in another triangle, the sums of the remaining angles in each triangle are equal.

Cor. 3. If one angle in a triangle be a right angle, the other two angles, together, are equal to a right angle; and each of them is, therefore, an acute angle.

Cor. 4. Every triangle has, at least, two acute angles.

Theorem XXIV.

All the inward angles of any rectilineal figure A B C D E *are together equal to twice as many right angles as the figure has sides, wanting four right angles.*



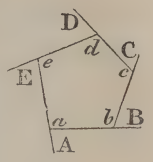
For from any point, F, within the figure, let lines be drawn to its angular points, dividing the figure into as many triangles as it has sides. Then, the interior angles of each triangle being together equal to two right angles (Theo. 23.), the interior angles of all the triangles are, together, equal to twice as many right angles as the figure has sides. But the interior angles of all the triangles are the inward angles of the figure, and the angles about the point F; and the angles about the point F are four right angles (Cor. 2. Theo. 6.). Hence, the interior angles of the figure and four right angles, are together equal to twice as many right angles as the figure has sides; or the interior angles of the figure, themselves, are equal to twice as many right angles as the figure has sides, wanting four right angles. Q. E. D.

Cor. 1. All the interior angles of any quadrilateral figure are together equal to four right angles.

Cor. 2. If the sum of two angles of a quadrilateral figure be equal to two right angles, the sum of the remaining angles is also equal to two right angles.

THEOREM XXV.

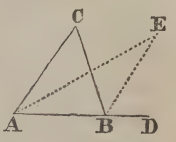
If the sides A B, B C, C D, &c. *of any rectilineal figure be produced, the outward, or exterior angles,* A, B, C, &c. *are together equal to four right angles.*



For let the inward angles be denoted, as in the figure, by the letters, *a*, *b*, *c*, &c., then each exterior angle and its corresponding interior one, as A and *a*, B and *b*, C and *c*, together make two right angles (Theo. 6.); therefore all the exterior and all the interior angles together make twice as many right angles as the figure has sides. But all the interior angles, and four right angles, are also together equal to twice as many right angles as the figure has sides (Theo. 24.). Hence the interior and the exterior angles of the figure are, together, equal to the interior angles of it and four right angles. If, therefore, the interior angles be omitted from each of these equal sums, the exterior angles will remain equal to four right angles. Q. E. D.

THEOREM XXVI.

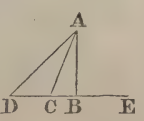
In any triangle A B C, *if one of the sides, as* A B, *be produced, and the outward angle* C B D, *and one of the inward and opposite angles, as* B A C, *be bisected by the lines* B E and A E, *meeting in* E, *the angle,* E *is equal to half the angle* A C D, *the remaining inward and opposite angle of the triangle.*



For the angle C B D is equal to the angles B A C and A C B together (Theo. 22.); therefore E B D, which is the half of C B D, is equal to the half of the angles B A C and B C A together, or to the angle B A E and the half of B C A. But E B D is also equal to the angles B A E and E together (Theo. 22.). Therefore the angles B A E and E together, are equal to the angle B A E and half the angle C together; and hence, by omitting the common angle B A E, we have the angle E equal to half of B C A. Q. E. D.

THEOREM XXVII.

If from a point A, *a perpendicular* A B *be drawn to any line* D E, *this perpendicular is the shortest line that can be drawn from the point* A *to the line* D E; *and of other lines as* A C *and* A D, *drawn from the same point* A *to the line* D E, *that which is nearer the perpendicular is less than the one more remote.*

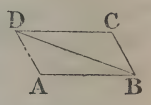


For the angle A B C being a right angle, the angle A C B is less than a right angle (Cor. 3. Theo. 23.); hence the side A B is less than A C (Theo. 12.). Again, because A C B is less than a right angle, A C D is greater than a right angle (Theo. 6.); and consequently the angle A D C is less than a right angle (Cor. 4. Theo. 23.);

and therefore, the side A C is less than the side A D (Theo. 12.). Q. E. D.

Theorem XXVIII.

In any parallelogram A B C D, *the opposite sides are equal to each other, and so also are the opposite angles; and the diagonal* B D *divides it into two equal triangles.*



For as A B and D C are parallel, the angles A B D and C D B are equal (Theo. 17.); and for a like reason the angles A D B and C B D are equal; and the side B D being common to both the triangles B D C and D B A, they are identical (Theo. 2.); the triangle A B D is therefore equal to the triangle B D C, the side A B to the side D C, A D to B C, and the angle A to the angle C; and as the two parts of the angle A D C are equal to the two corresponding parts of the angle A B C, the whole angles A D C and A B C are also equal. Q. E. D.

Cor. If one angle of a parallelogram be a right angle, all its angles are right angles, and consequently all the angles of a rectangle are right angles, and a parallelogram which has one oblique angle has all its angles oblique.

Theorem XXIX.

Any quadrilateral, A B C D (Fig. Theo. 28.), *whose opposite sides* A B, C D, *and* A D, B C *are respectively equal, is a parallelogram.*

For let the diagonal B D be drawn; then as the triangles B A D, D C B, have the sides A B and D C equal, and also A D equal to B C, and the side B D common to both the triangles, they are identical (Theo. 5.); therefore the angles B D C and A B D are equal, and so are the angles A D B and C B D. Hence A B is parallel to C D, and A D to B C (Theo. 18.); and the figure is therefore a parallelogram. Q. E. D.

Cor. A square is a parallelogram, and hence also all the angles of a square are right angles (Cor. Theo. 28.).

Theorem XXX.

The lines A D *and* B C (Fig. Theo. 28), *which join the corresponding extremities* A *and* D, B *and* C, *of the equal and parallel lines* A B *and* C D, *are themselves equal and parallel.*

For let the points D and B be joined; then because A B and C D are parallel, the angles A B D and C D B are equal (Theo. 17.); and therefore, as A B is equal to C D, and B D common to both the triangles A B D and C D B, they are equal in all respects (Theo. 1.); consequently A D is equal to B C, and the angle A D B to the alternate angle D B C; and, therefore, A D and B C are parallel (Theo. 18.). Q. E. D.

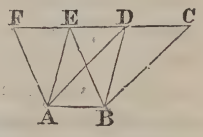
Theorem XXXI.

The diagonals A C, B D, *of any parallelogram* A B C D, *bisect each other.*

For as the parallel lines A B, C D are cut by the lines A C and B D, the alternate angles B A E and D C E are equal (Theo. 17.), and also the angles E B A and C D E; and as A B is also equal to C D (Theo. 28.), the triangles A B E, D C E are identical (Theo. 2.), and have A E equal to E C, and B E equal to E D. Q. E. D.

Theorem XXXII.

If any two parallelograms, as A B C D, A B E F, *be on the same base* A B, *and between the same parallels* A B, *and* F C, *these parallelograms are equal to each other.*

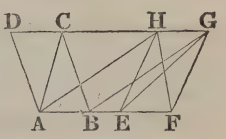


For F E and D C are equal, being each equal to A B (Theo. 28.); and if the common part E D be added to each, the wholes F D and E C will be equal. Now A F and B E are equal, and so are A D and B C (Theo. 28.); hence the triangles A D F and B C E are identical (Theo. 5.). If therefore each of these equal triangles be taken from the whole figure A B C F, the remainders, or the parallelograms A B C D, and A B E F, must be equal. Q. E. D.

Cor. If the diagonals A E and B D be drawn, the triangles A B E, A B D, which are halves of the equal parallelograms A B E F, A B C D, are equal to each other.

Theorem XXXIII.

Parallelograms as A B C D, E F G H, *which are upon equal bases,* A B *and* E F, *and between the same parallels* A F *and* D G, *are equal to each other.*



For H G, being equal and parallel to E F, is equal and parallel to A B; hence A H and B G are equal and parallel (Theo. 30.); and A B G H is therefore a parallelogram. But the parallelograms B D and B H, being on the same base A B, and between the same parallels A B and D G, are equal; and B H and H F, being on the same base H G, and between the same parallels H G and A F are likewise equal (Theo. 32.). Hence B D and H F, being each equal to A G, are equal to each other. Q. E. D.

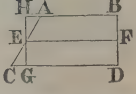
Cor. 1. If the diagonals A C and F H be drawn, the triangles A B C and E F H, which are halves of the equal parallelograms B D and E G, are equal.

Cor. 2. As all triangles on the same base, or equal bases, and between the same parallels, are equal, if therefore a triangle and a

parallelogram be on the same base, or on equal bases, and between the same parallels, the parallelogram is double the triangle.

THEOREM XXXIV.

If A C, *one of the sides of any trapezoid* A B D C, *be bisected in* E, *and* E F *be drawn parallel to* A B *or* C D, *the parallel sides of the trapezoid, cutting* B D, *the remaining side, in* F, E F *is equal to half the sum of* A B *and* C D.



For through E draw G H parallel to D B, meeting C D in G and B A, produced, in H. Then E F is equal to B H or G D (Theo. 28.); and as A E is equal to E C, the angle A E H to the vertical angle G E C (Theo. 8.), and the angle E A H to the alternate angle E C G (Theo. 17.), the triangles E A H and E C G are identical (Theo. 2.), and have the sides A H and C G equal. Hence E F is as much greater than A B as it is less than C D, and it is consequently equal to half their sum. Q. E. D.

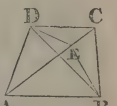
THEOREM XXXV.

If two triangles as A B C, D E F, *have two sides* A B, B C *of the one, equal respectively to two sides* D E, D F *of the other, and the contained angles* F D E, A B C *together equal to two right angles, the triangles are equal.*

For conceive the point C to be laid on the point F, and the line C B on the line F D; then because these lines are equal, the points B and D will concide. Let the point A fall at G; then as the angles A B C and F D E, or G D F and F D E are together equal to two right angles, the lines G D and D E form one straight line (Theo. 7.); and consequently as D E is equal to D G, the triangles F D E and G D F, or F D E and A B C are equal (Cor. 1. Theo. 33.). Q. E. D.

THEOREM XXXVI.

If two equal triangles, as A C B, A D B, *be on the same base* A B, *and on the same side of it, the line* D C, *which joins their vertices, is parallel to the base* A B.



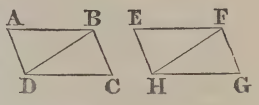
For if D C is not parallel to A B, let D E meeting A C in E be parallel to A B, and join B E. Then the triangle A D B is equal to the triangle A E B (Cor. Theo. 32.); but the triangle A D B is also equal to the triangle A B C, by condition; hence the triangles A B E and A B C are equal, a part to the whole, which is impossible. No line therefore drawn from D, except that of which D C is a part, can be parallel to A B, and D C is consequently parallel to A B. Q. E. D.

Cor. 1. Equal parallelograms, on the same base, and on the same side of it, are between the same parallels.

Cor. 2. Equal triangles, or equal parallelograms on equal bases, in the same straight line and on the same side of it, are between the same parallels.

Theorem XXXVII.

If any two parallelograms, A C, E G, *have two sides* A B, A D, *and the contained angle* B A D *in the one, equal to two sides* E F, E H, *and the contained angle* F E H *in the other, these parallelograms are equal.*



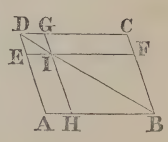
For let the diagonals D B, and F H be drawn. Then the triangles A B D and E F H are identical (Theo. 1.); and consequently as the parallelograms are doubles of these equal triangles, they are equal to each other. Q. E. D.

Cor. 1. Rectangles contained by equal straight lines are equal to each other.

Cor. 2. The squares on equal lines are equal to each other.

Theorem XXXVIII.

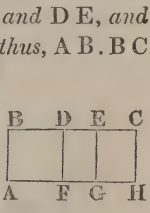
If A B C D *be any parallelogram, and* B D *a diagonal of it; and if* E I F *be drawn parallel to* A B *or* C D, *and* G I H *parallel to* A D *or* B C, *making the parallelograms* H F *and* E G *about the diagonal* B D; *the remaining parts* A I *and* I C, *called the complements of the parallelograms* H F *and* E G, *are equal to each other.*



For the parallelograms A C, H F, and E G, being each bisected by the line D I B, the triangles A B D and D B C are equal; and so are the triangles B H I and B F I, D E I and D G I (Theo. 28.); therefore the remaining or complementary parts A I and I C must also be equal. Q. E. D.

Theorem XXXIX.

Let A B *be any line, and* B C *another, divided into any number of parts* B D, D E, *and* E C; *the rectangle contained by* A B *and* B C *is equal to the rectangles contained by* A B *and* B D, A B *and* D E, *and* A B *and* E C; *an equality which is commonly expressed thus,* A B . B C = A B . B D + A B . D E + A B . E C.



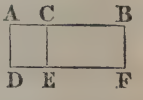
For let A C be the rectangle contained by A B and B C, and let D F and E G be drawn parallel to A B; then A C is the sum of the rectangles A D, F E, and G C. Now A D is contained by A B and B D, F E by F D and D E, and G C by G E and E C; and as D F and E G are each equal to A B, these rectangles are equal to the rectangles contained by A B and B D, A B and D E, and A B and E C. Hence A B . B C = A B . B D + A B . D E + A B . E C. Q. E. D.

If A B be represented by a, B D, D E, and E C by b, c, and d respectively, then B C will be represented by $b + c + d$, and the rectangle $a.\overline{b + c + d}$ will be equal to $ab + ac + ad$.

Cor. If a straight line be divided into any number of parts, the rectangles under the whole line and each of the parts of it, will be equal to the square of the whole line; for if A B were equal to B C, B H would be the square of A B or B C.

Theorem XL.

If a straight line A B, *be divided into any two parts* A C, C B, *the rectangle of the whole line* A B, *and one of the parts, as* A C, *will be equal to the square of that part, and the rectangle contained by the two parts* A C *and* B C. *Or* $AB.AC = AC^2 + AC.BC$.



For let A D be perpendicular to A B and equal to A C, and let D F be parallel to A B, and B F, C E, each parallel to A D. Then as C E is equal to A D or A C, and the angle at A is a right angle, A E is the square of A C, and C F is the rectangle of B C and C E, or of B C and C A. But the sum of the square A E and the rectangle E B, is the whole rectangle A F, which is contained by A B and A D, or by A B and A C. Hence $AB.AC = AC^2 + AC.BC$. Q. E. D.

Cor. 1. If A C, or A D be represented by a, and B C by b; then A B will be represented by $a + b$, and $a.\overline{a + b}$ will be equal to $a^2 + ab$.

Cor. 2. $2AB.AC = 2AC^2 + 2AC.BC$.

Theorem XLI.

If a straight line, as A B, *be divided into any two parts* A F *and* F B, *the square of the whole line* A B *is equal to the squares of the two parts* A F *and* F B, *and twice the rectangle contained by those parts. That is* AB^2 *or* $\overline{AF+FB}^2 = AF^2 + BF^2 + 2AF.FB$.

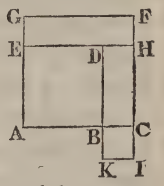
For let A C be the square on A B, and F I the square on F B and produce F G and I G, till they meet D C and A D in E and H. Then as F E is equal to B C, and I H to A B, and A B is equal to B C, therefore F E, and H I are equal; and if from the equal lines F E and H I, the equal lines F G and G I be taken, the remaining parts G E and H G will be equal; and because H E is a parallelogram, H D is equal to G E, and D E to H G (Theo. 28.); consequently the sides of the parallelogram H E are all equal; and as the angle D is a right angle (Cor. Theo. 29.), H E is a square, and it is described on the line HG, or it is the square of the equal line A F. Further, the figures A G and G C are equal to two rectangles contained by A F and F B; for F G and G I are each equal to F B, and I C is equal to A F. Therefore

the square of A B is equal to the squares of A F and F B, and twice the rectangle of A F and F B. Or if A F be represented by a, and F B by b, then $\overline{a+b}^2 = a^2 + b^2 + 2ab$. Q. E. D.

Cor. If a line be bisected, the square of the whole line will be equal to four times the square of half the line.

Theorem XLII.

Let A C *and* B C *be any two lines, then the square of* A B, *the difference of* A C *and* B C, *is less than the sum of the squares of* A C *and* B C *by twice the rectangle of* A C *and* B C. *Or* $\overline{AC-BC}^2 = AC^2 + BC^2 - 2AC \cdot BC$.



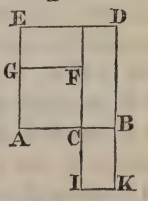
For let A B D E be the square on the difference A B, A C F G the square on the line A C, and B C I K the square on B C, and produce E D to H.

Now A D is less than the two squares A F and B I by the rectangles G H and H K; but G F is equal to A C; and if from the equal lines, A C and A G, the equal parts, A B and A E, be taken away, the remaining parts, G E and B C, are equal; consequently E F is equal to the rectangle of A C and B C.

Again, because A B and B D are equal, and B C and B K are also equal, A C is equal to D K; and B C is also equal to K I; consequently D I is equal to the rectangle contained by A C and B C. Hence the two figures, E F and D I, are two rectangles equal to those contained by A C and B C: and therefore the square of A B is less than the squares of A C and B C by twice the rectangle of A C and B C. Or if A C be represented by a, and B C by b, then $\overline{a-b}^2 = a^2 + b^2 - 2ab$. Q. E. D.

Theorem XLIII.

If A B *and* A C *be any two unequal lines, the difference of their squares will be equal to a rectangle under their sum and difference.* Or $AB^2 - AC^2 = \overline{AB+AC} \cdot \overline{AB-AC}$.



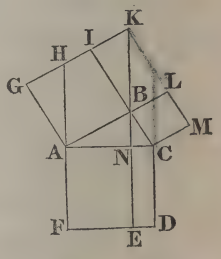
For let A B D E be the square of A B, and A C F G the square of A C. Produce D B till B K is equal to A C; draw K I parallel to A B or E D, and produce F C both ways till it meet I K and E D.

Then the rectangles E F and C D together form the difference of the two squares A D and A F. But the rectangles E F and B I are equal, for G F and B K are each equal to A C, and G E is equal to B C, being each equal to the difference of A B and A C, or of their equals, A E and A G. Therefore the rectangles E F and C D are

together equal to the rectangles B I and C D, or to the whole rectangle D I; and consequently D I is equal to the difference of the squares A D and A F. But D I is a rectangle contained under D K the sum, and K I the difference of A B and A C. Hence the difference of the squares of A B and A C is equal to the rectangle of their sum and difference. Or if A B be represented by a, and A C by b, then $a^2 - b^2 = \overline{a+b} \cdot \overline{a-b}$. Q. E. D.

Theorem XLIV.

In any right-angled triangle A B C, *the square on* A C, *the side opposite the right angle* B, *is equal to the sum of the squares described on* A B *and* B C, *the sides including the right angle.*

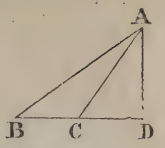


For let A D be the square on A C, A I the square on A B, and C L the square on B C. Produce A F till it meet G I in H; and through B draw K B N E parallel to A F, meeting G I, produced, in K. Then because the angle C A H, adjacent to C A F, is a right angle, it is equal to B A G: from each take away the common angle B A H, and there remains the angle B A C, equal to the angle G A H. But the angles A G H and A B C, being right angles, are equal to each other, and A B is equal to A G. Hence A H is equal to A C or A F (Theo. 2.); and therefore the parallelogram A K is equal to the rectangle A E (Theo. 33.). But the parallelogram A K is equal to the square A I (Theo. 32.), for they are on the same base, A B, and between the same parallels, A B and G K. Consequently the square A I, and the rectangle A E, being each equal to the parallelogram A K, are equal to one another. In the same way, by producing D C and L M, may the square B M be shown to be equal to the rectangle C E; therefore the two squares A I and B M together are equal to the whole square A D. Q. E. D.

Cor. Hence the square of either of the sides including the right angle, is equal to the difference of the squares of the hypothenuse and the other side: or equal to the rectangle of the sum and difference of the hypothenuse and the other side.

Theorem XLV.

In any triangle, A B C, *obtuse-angled, as at* C, *if a perpendicular*, A D, *be drawn from the vertical angle* A *to the base* B C *produced, the square of* A B, *opposite the obtuse angle, is greater than the squares of the other two sides* B C *and* A C, *by twice the rectangle of* B C *and* C D.

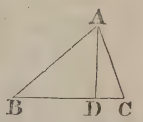


For the square of A B is equal to the squares of B D and D A (Theo. 44.); and the square of B D is equal to the squares of B C and C D, and twice the rectangle of B C and C D (Theo. 41.). Hence the square of A B is equal to the squares of B C, C D, and D A, and twice the rectangle of B C and C D. But the squares of C D and D A are together equal to the square of A C; hence the square of A B is equal to the squares of B C and C A, and twice the rectangle of B C and C D: or the square of A B is greater than the squares of B C and C A by twice the rectangle of B C and C D. Q. E. D.

Cor. $2\,B\,C\,.\,C\,D = B\,A^2 - B\,C^2 - C\,A^2 = B\,A^2 - (B\,C^2 + C\,A^2)$.

Theorem XLVI.

In any triangle A B C, *if* A D *be a perpendicular drawn from the vertical angle* A, *on the opposite side* B C, *the square of* A B, *opposite an acute angle, as* C, *is less than the squares of the other two sides* A C *and* B C *by twice the rectangle of* B C *and* D C.



For the square of A C is equal to the squares of A D and D C (Theo. 44.); and the square of B C is equal to the squares of B D and D C, and twice the rectangle of B D and D C (Theo. 41.). Hence the squares of A C and B C together are equal to the squares of B D and D A, twice the square of D C, and twice the rectangle of B D and D C. But the squares of B D and D A are together equal to the square of B A; and twice the square of D C, and twice the rectangle of B D and D C, are together equal to twice the rectangle of B C and D C (Cor. 2. Theo. 40.). Hence the squares of A C and B C are equal to the square of A B, and twice the rectangle of B C and D C; or the square of A B is less than the sum of the squares of A C and B C by twice the rectangle of B C and D C. Q. E. D.

Cor. $2\,B\,C\,.\,C\,D = (B\,C^2 + A\,C^2) - B\,A^2$.

Theorem XLVII.

In any triangle A B C (see the two preceding figures), *if* A D *be a perpendicular from the vertical angle* A, *on the base* B C, *or on the base produced; the difference of the squares of* A B *and* A C *is equal to the difference of the squares of* B D *and* D C.

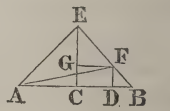
For the square of A B is equal to the squares of A D and D B, and the square of A C is equal to the squares of A D and D C (Theo. 44.). Hence the difference of the squares of A B and A C is equal to the difference between the sum of the squares of A D and D B, and the sum of the squares of A D and D C; or, as the square of A D is common to each of these sums, the difference of the squares of A B

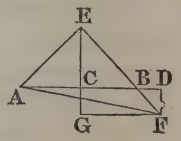
and A C is equal to the difference of the square of B D and D C. Q. E. D.

Cor. As the difference of the squares of any two lines is equal to a rectangle under their sum and difference, the rectangle under the sum and difference of A B and A C, any two sides of a triangle, is equal to the rectangle under the sum and difference of B D and D C, the segments of the third side, made by a perpendicular from the opposite angle.

Theorem XLVIII.

If any straight line A B *be bisected in* C, *and any other point* D *be taken, either in the line, or in the line produced, the squares of the unequal parts,* A D *and* D B, *will together be double the squares of* A C, *half the line, and* C D, *the distance between the points of section.*





For draw C E perpendicular to A B, and make it equal to A C or C B; join A E and E B; and through D draw D F parallel to C E, meeting E B, or E B produced, in F; and through F draw G F parallel to A B, meeting E C, or E C produced, in G. Then because A C and C E are equal, and the angle A C E is a right angle, each of the angles, C A E and C E A, is half a right angle. For a like reason each of the angles, C E B and C B E (or D B F), is half a right angle, and consequently the whole angle A E F is a right angle. And because D F is parallel to C E, F D B is equal to E C B (Theo. 19.), and it is therefore a right angle; hence B F D is half a right angle; and consequently B D is equal to D F, or C G (Theo. 4.); and for a like reason C D or G F is equal to G E.

Now the square of A E is equal to the sum of the squares of A C and C E (Theo. 44.); or, as these two lines are equal, the square of A E is double the square of A C. In the same way it may be shown that the square of E F is double the square of G F or C D. And as A E F is a right angle, the squares of A E and E F, which have been shown to be equal to double the squares of A C and C D, are together equal to the square of A F. But the squares of A D and D F, or of A D and D B, are also equal to the square of A F (Theo. 44.). Therefore the squares of A D and D B are together equal to double the squares of A C and C D. Q. E. D.

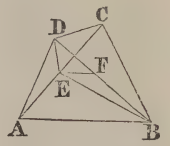
Theorem XLIX.

If the base A B *of a triangle* A B C *be bisected in* D, *and the point* D *be joined to the vertex* C, *the squares of* A C *and* B C, *the other sides of the triangle, will together be equal to double the squares of* A D *and* D C.

For let C E be a line drawn from C, perpendicular to A B; then because the square of A C is equal to the squares of A E and E C, and the square of B C is equal to the squares of B E and E C (Theo. 44.), the squares of A C and B C are together equal to the sum of the squares of A E and E B, and twice the square of E C. But the squares of A E and E B are together equal to double the squares of A D and D E (Theo. 48.); hence the squares of A C and B C are together equal to twice the sum of the squares of A D, D E, and E C. And as the squares of D E and E C are equal to the square of D C, double the squares of D E and C E are equal to double the square of D C. Therefore the squares A C and B C are equal to double the squares of A D and D C. Q. E. D.

Theorem L.

In any quadrilateral A B C D, *the sum of the squares of the sides* A B, B C, C D, *and* D A, *is equal to the sum of the squares of the diagonals* A C *and* B D, *and four times the square of* E F, *which joins the middle points of the diagonals.*

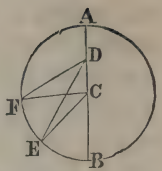


For the squares of A D and D C are, together, equal to twice the squares of A E and E D; and the squares of A B and B C are, together, equal to twice the squares of A E and E B (Theo. 49.); therefore the squares of A B, B C, C D, and D A together, are equal to four times the square of A E, twice the square of B E, and twice the square of D E. But as the squares of B E and D E are equal to twice the squares of B F and F E, twice the squares of B E and D E are equal to four times the squares of B F and F E. Hence the squares of A B, B C, C D, and D A, are equal to four times the squares of A E, B F, and F E. But the square of A C is equal to four times the square of its half A E, and the square of B D is equal to four times the square of its half B F (Theo. 41. Cor.); therefore the squares of A B, B C, C D, and D A, are equal to the squares of A C and B D, and four times the square of E F. Q. E. D.

Cor. If A B C D be a parallelogram, then, as the diagonals of a parallelogram bisect each other (Theo. 31.), the squares of the four sides of any parallelogram are equal to the squares of its diagonals.

Theorem LI.

If any point D *be taken in* A C B, *the diameter of a circle; that part of the diameter* D B, *which passes through the centre* C, *is greater than any other line* D E *that can be drawn from the point* D *to the circumference of the circle; and* D E *is greater than any other line* D F *similarly drawn from* D *to the circumference, but at a greater distance from* D B.

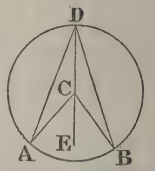


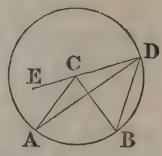
For join C E, C F; then as C E is equal to C B, D C and C E are, together, equal to D B; and as D C and C E, together, are greater than D E (Theo. 15.), D B is also greater than D E. Again D C and C E, two sides of the triangle D C E, are respectively equal to D C and C F, two sides of the triangle D C F, but the angle D C E is greater than the angle D C F; therefore the base D E of the triangle D C E is greater than the base D F of the triangle D C F. (Theo. 13.).

Again D A, the difference of C A and C D, is the same as the difference of C F and C D, which (Theo. 16.) is less than F D.

Theorem LII.

An angle A C B *at the centre of a circle is double the angle* A D B *at the circumference, when both of them stand on the same arc* A B.





For join D C, and produce it to E; then the angle A C E is equal to the sum of the angles C A D and C D A (Theo. 22.). But as A C is equal to C D, the angles C A D and C D A are equal (Theo. 3.); therefore the angle A C E is double of either of them, as A D C. For a like reason B C E is double of B D C; and, consequently, by addition or subtraction, the angle A C B is double the angle A D B. Q. E. D.

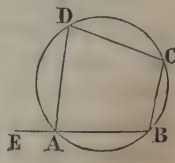
Cor. 1. As the angle A C B, at the centre, is measured by the arc A B on which it stands, the angle A D B, at the circumference, is measured by half the arc A B on which it stands.

Cor. 2. All angles in the same segment of a circle, or standing on the same arc, are equal to each other; for each of them is equal to half the angle at the centre, standing on the same arc.

Cor. 3. The angle in a semicircle is a right angle. For when A C and C B (*first fig. of this prop.*) become one straight line, A D B is a semicircle, and the angles A C E and B C E are together equal to two right angles; whence A D B, which is half the sum of A C E and B C E, is in that case equal to one right angle.

Theorem LIII.

The sum of any two opposite angles, B A D *and* B C D, *of a quadrangle* A B C D *inscribed in a circle, is equal to two right angles.*



For the angle B A D is measured by half the arc B C D, and the angle B C D by half the arc B A D (Cor. 1. Theo. 52.); therefore the sum of the angles B A D and B C D, is measured by half the whole circumference. But half the whole circumference is the measure of two right angles (Theo. 6. Cor. 3.).

Hence the angles B A D and B C D are, together, equal to two right angles. Q. E. D.

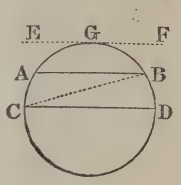
Theorem LIV.

If any side, B A, *of a quadrilateral* A B C D (see the last figure), *inscribed in a circle, be produced, the outward angle*, D A E, *is equal to the inward and opposite angle* C.

For the angles D A B and D A E are equal to two right angles (Theo. 6.), and the angles D A B and D C B are also equal to two right angles (Theo. 53.). Hence, by omitting the common angle D A B from each sum, the remaining angles, D A E and D C B, are equal. Q. E. D.

Theorem LV.

If, in a circle A B D C, *there be drawn two parallel chords* A B, C D, *the intercepted arcs* A C *and* B D *will be equal.*

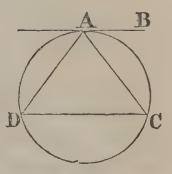


For join B C. Then, because A B and C D are parallel, the alternate angles A B C and D C B are equal (Theo. 17.). But the angle A B C is measured by half the arc A C, and the angle D C B by half the arc D B (Cor. 1. Theo. 52.). Whence the halves of A C and B D are equal, and consequently the whole arcs A C and B D are equal. Q. E. D.

Cor. If A B move parallel to itself, till it coincide at G with the tangent E G F, the intercepted arcs, G C and G D, will be equal.

Theorem LVI.

If A B *be a tangent to a circle, and* A C *a chord drawn from* A, *the point of contact, the angle* B A C *is equal to any angle in the alternate segment* A D C.

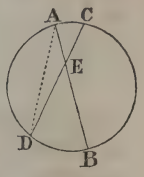


For from C draw the chord D C parallel to the tangent A B, and join A D. Then, as the arcs A C and A D are equal (Cor. Theo. 55.), the angles A D C and A C D are equal, being measured by the halves of the equal arcs A C and A D (Cor. 1. Theo. 52.). But the angle A C D is equal to the alternate angle B A C (Theo. 17.); therefore the angle B A C is equal to the angle A D C. And as the angle A D C is equal to any angle in the segment A D C (Theo. 52. Cor. 2.), the angle B A C is also equal to any angle in the alternate segment A D C. Q. E. D.

Cor. As the angle A D C is measured by half the arc A C, the angle B A C, made by the tangent A B, and the chord A C, is also measured by half the intercepted arc A C.

Theorem LVII.

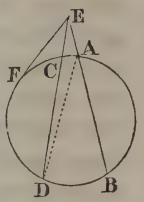
The angle D E B *formed within any circle* A C B D, *by the intersection of two chords* A B, C D, *is measured by half the sum of the intercepted arcs* A C *and* B D.



For join A D. Then the angle A D E or A D C is measured by half the arc A C, and the angle D A E, or D A B, by half the arc B D (Cor. 1. Theo. 52.). But the angle D E B is equal to the sum of the angles D A E and A D E (Theo. 22.); it is therefore measured by half the sum of the arcs A C and B D. Q. E. D.

Theorem LVIII.

If two chords A B, C D, *of the circle* A B D C, *meet when produced in a point* E *without the circle, the angle* E *is measured by half the difference of the intercepted arcs* A C *and* B D.

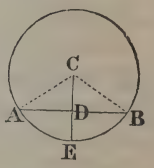


For join A D. Then the angle A D C is measured by half the arc A C, and the angle D A B by half the arc D B (Cor. 1. Theo. 52.). But the angle D E B is equal to the difference of the angles D A B and E D A (Theo. 22. Cor.); therefore the angle D E B is measured by half the difference of the arcs A C and B D. Q. E. D.

Cor. If one of the lines, as E C D, revolve round the point E, till the points C and D coincide in F, E F will then be a tangent to the circle, and the angle F E A will be measured by half the difference of the intercepted arcs A F and F B.

Theorem LIX.

A line C D E *drawn from the centre* C *to the middle of the chord* A B *is perpendicular to that chord; and* C D E, *drawn from the centre* C, *perpendicular to the chord* A B, *bisects both the chord and the arc* A E B.



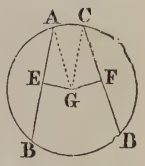
For let the two radii C A, C B be drawn, then, if A B be bisected in D, the two triangles A C D, B C D, have the sides A C and B C equal, A D and B D equal, and D C common to both; they are therefore identical (Theo. 5.), and have the adjacent angles A D C and B D C equal; these angles are consequently right angles, and C D is therefore perpendicular to A B.

Again, if C D be perpendicular to A B, the angles C D A and C D B are equal; and C A being equal to C B, the angle C A B, or C A D, is equal to the angle C B A, or C B D (Theo. 3.); therefore A C D

and B C D, the remaining angles of each triangle, are also equal. (Theo. 23. Cor. 1.) Hence, as A C is equal to C B, the triangles A D C and B D C will be identical (Theo. 2.), and consequently the side A D is equal to the corresponding side B D; and, as the angle A C D is equal to the angle B C D, the arc A E is equal to the arc B E. Q. E. D.

Theorem LX.

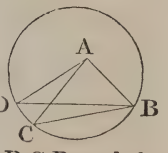
Let A B, C D *be any two chords in a circle* A B D C, *and let* G E, G F *be perpendiculars drawn from the centre* G, *on the chords* A B *and* C D. *If* A B *and* C D *are equal,* E G *and* G F *are equal; or if* E G *and* G F *are equal,* A B *and* C D *are also equal.*



For draw the two radii A G, G C; then as A B and C D are bisected in E and F (Theo. 59.), if they are equal, their halves A E and C F are equal. But the square of A G is equal to the sum of the squares of A E and E G, and the square of G C is equal to the sum of the squares of G F and F C (Theo. 44.); and as A G and G C are equal, their squares are equal. Hence the sum of the squares of A E and E G is equal to the sum of the squares of C F and F G; and if the squares of the equal lines A E and C F be taken from each of these equal sums, the square of E G will remain equal to the square of G F, and consequently G E is equal to G F. In the same way it may be shown, that when G E is equal to G F, A E is equal to C F, therefore A B and C D, the doubles of those lines, are equal.

Theorem LXI.

If B D *and* B C *be two unequal chords in a circle, the angle* B A D *at the centre, subtended by the greater chord* B D, *is greater than the angle* B A C *subtended by the less.*



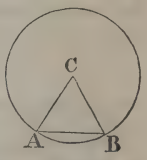
For as the sides A D, A B, of the triangle D A B, are equal to the sides A C, A B, of the triangle C A B, but D B is greater than B C, therefore the angle D A B is greater than the angle C A B, (Theo. 14.).

Cor. 1. As the angle D A B is measured by the arc D C B, and the angle C A B by the arc B C, therefore the arc D C B, subtended by the greater chord, is greater than the arc B C, subtended by the less.

Cor. 2. In the same circle equal chords subtend equal arcs, or equal angles, whether at the centre or circumference; and equal arcs, or equal angles, whether at the centre or the circumference, are subtended by equal chords.

Theorem LXII.

If A C B, *an angle at the centre of a circle, be the sixth part of four right angles, or the third part of two right angles,* A B, *the chord of the arc which measures the angle* A C B, *is equal to the radius of the circle.*

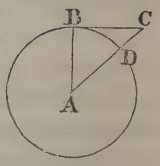


For as all the interior angles of a triangle are, together, equal to two right angles (Theo. 23.), if A C B be the third part of two right angles, the remaining angles A and B will, together, be equal to two-thirds of two right angles. And as A C and B C are equal, the angles A and B are equal (Theo. 3.); and consequently each of these is equal to the third part of two right angles, or to the angle A C B. Hence the triangle A B C, being equiangular, is equilateral (Cor. Theo. 4.), or A B is equal to A C or B C.

Remark. The circumference of a circle, or the measure of four right angles, is commonly divided, in practice, into 360 equal parts, called degrees; therefore the chord of 60 degrees, or the chord of the measure of the sixth part of four right angles, is, in any circle, equal to the radius; and hence if the chords of every arch in a circle of a given radius were arranged on a line, such a line, called a line of chords, would afford a convenient practical method of describing an angle, whose measure might be given in degrees, &c.

Theorem LXIII.

If A B *be the radius of a circle, then* B C, *a perpendicular on its extremity* B, *is a tangent to the circle*



For from any other point C, in the line B C, draw C D A to the centre A, meeting the circle in D. Then, because the angle A B C is a right angle, the angle A C B is less than a right angle (Cor. 3. Theo. 23.); therefore A C is greater than A B (Theo. 12.), or than its equal A D; and consequently the point C is without the circle. In the same way every other point of the line B C, except the point B, may be shown to be without the circle; and therefore, as the line B C meets the circle in the point B only, it is a tangent to the circle. Q. E. D.

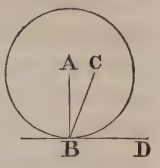
Theorem LXIV.

If B C (see the last figure) *touch the circumference of the circle in* B, *the radius* A B *will be perpendicular to* B C.

For as B C touches the circumference in the point B only, every other point of B C is without the circle; A B is therefore the shortest line that can be drawn from the point A to the line B C; hence A B is perpendicular to B C (Theo. 27.).

Theorem LXV.

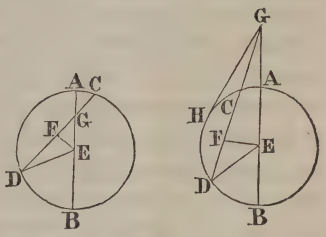
If B D *touch the circumference of a circle in* B, *then* B A, *drawn perpendicular to* B D, *will pass through the centre of the circle.*



For if the centre of the circle be not in the line A B, let any point C out of that line be the centre of the circle, and join B C. Then the angle C B D being a right angle (Theo. 64.), it is equal to A B D, which is also, by condition, a right angle ; that is, the less angle is equal to the greater, which is impossible. Hence, as no point out of the line B A can be the centre of the circle, the line B A passes through the centre. Q. E. D.

Theorem LXVI.

In any circle A C D B, *if the chord* C D *and the diameter* A B, *meet each other in* G, *the rectangle of* G A, G B, *the segments of the one, will be equal to the rectangle* G C, G D, *the segments of the other.*



For let D E be joined, and the perpendicular E F drawn to D C. Then, because D E is equal to E B, G B is the sum of G E and E D ; and, because D E is equal to E A, A G is the difference of D E and E G. Again, because D F is equal to F C (Theo. 59.), G C is the difference of the segments of the base D F and F G, made by the perpendicular E F ; and D G is the sum of the segments D F and F G.

But the rectangle under the sum and difference of D E and E G is equal to the rectangle under the sum and difference of D F and F G (Theo. 47. Cor.) ; whence the rectangle of G B and G A is equal to the rectangle of G D and G C. Q. E. D.

Cor. 1. As the rectangle of A G and G B, the segments of the diameter, is equal to the rectangle of G C and G D, the segments of any other line made by its intersection with the diameter ; it is evident that if any two lines drawn through the same point cut the circumference of a circle, the rectangle of the segments of the one is equal to the rectangle of the segments of the other.

Cor. 2. If, when the point of meeting is without the circle, the line G C D revolve about the point G, till the points C and D coincide, as in H, G H is a tangent to the circle ; and the rectangle of G C and G D is then the square of G H ; and hence also a tangent to the circle, drawn from G, on the other side of the diameter, is equal to the tangent G H ; or tangents drawn from the same point to the same circle are equal to each other.

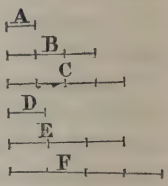
OF PROPORTION.

PROPORTION is the ratio, or numerical relation, which one quantity bears to another.

Quantities between which proportion can exist, must be of the same kind, as a line and a line, a surface and a surface, a solid and a solid.

A greater quantity is said to be a multiple of a less, when it contains the less a certain number of times without any remainder; and quantities so related are said to have the same ratio or proportion to each other, that unity, representing the less, has to as many such units as are contained in the greater.

If a quantity, as A, be contained exactly a certain number of times in another quantity, B, the quantity A is said to measure the quantity B; and if the same quantity A be contained exactly a certain number of times in another quantity C, A is also said to be a measure of the quantity C, and it is called a common measure of the quantities B and C; and it is evident that the quantities B and C bear the same relation to each other that the numbers do which represent the multiple that each quantity is of the common measure A.

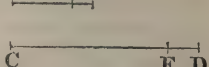


Thus, if B contain A three times, and C contain A also three times, B and C, being equimultiples of the quantity A, are equal to each other. And if B contain A three times, and C contain A four times, the proportion between B and C is the same as the proportion between the numbers 3 and 4.

Again, if a quantity, D, be contained as often in another quantity, E, as A is contained in B, and as often in another quantity, F, as A is contained in C, the ratio of E to F, or the proportion between them, is the same as the proportion between B and C, and in that case the quantities, B, C, E, and F, are said to be proportional quantities; a relation which is commonly expressed thus, B : C :: E : F.

Hence, in finding the proportion between two quantities, it is necessary to refer to a quantity which is conceived to measure them both, and the method of finding such a common measure may be thus explained by an example.

Suppose it were required to find a common measure of the quantities A B and C D. From the greater, C D, take the less, A B, as often as it is contained in it; and from A B take the remainder, E D, as often as it is contained in it; and from E D, the first remainder, take F B, the second, as often as it is contained in



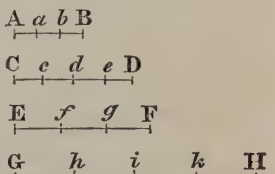
it, and so on, till nothing remains; then the last remainder is a common measure both of the original quantities, A B and C D, and of the several successive remainders. For as the last remainder measures the preceding one, and is also a measure of itself, it is a measure of the several parts of which the *next preceding remainder* is composed; and it is therefore a measure both of each preceding remainder, and of the original quantities A B and C D.

Let us, as an instance, suppose that C D contains A B thrice, with the remainder D E; and that A B contains D E twice, with the remainder B F; and that E D contains B F twice exactly. Then A F, which is twice E D, contains B F four times; and therefore A B contains B F five times. Whence C E, which contains A B three times, contains B F fifteen times; and as E D contains B F twice, the whole C D contains B F seventeen times; and B F is therefore a common measure of A B and C D.

The quantities to be compared may, however, be so related to each other, that the subdivision of the remainders, in the manner above described, will never terminate. But even in that case the operation may be continued till a quantity so small be obtained, that, on its being applied as a measure of the two given quantities, the remainders will be less than any quantities that can be assigned; and hence the difference of the proportion between the two given quantities, and the proportion between the numbers which represent the nearest multiple that each of them is of this approximate common measure, will be indefinitely small; and the proportions may therefore be considered as identical.

Theorem LXVII.

Like multiples of any two quantities, A B *and* C D, *have the same proportion as the quantities themselves.*

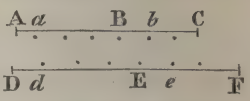


Let A B be to C D as any number (say 3) to any other number, as 4, or let A B contain three such equal parts as those of which C D contains four. Let E *f*, *f g*, *g* F, be any like multiples of A *a*, *a b*, *b* B; G *h*, *h i*, *i k*, *k* H, the same multiples of C *c*, *c d*, *d e*, *e* D; then the whole of E F is evidently the same multiple of the whole of A B, and the whole of G H of the whole of C D, that each part of the one is of the corresponding part of the other. And as the parts A *a*, *a b*, *b* B, C *c*, *c d*, &c, are all equal, their like multiples E *f*, *f g*, G *h*, &c. are also equal. Hence E F is to G H as 3 is to 4, which is the same proportion that A B has to C D. In the same way may the property be proved, whatever numerical relation A B may have to C D. Q. E. D.

Cor. As A B and C D are like parts of E F and G H, like parts of quantities have the same proportion as the wholes.

Theorem LXVIII.

In any four quantities, A B, B C, D E, *and* E F, *if* A B : B C :: D E : E F, *then alternately* A B : D E :: B C : E F.



If A B be to B C, or D E to E F, as any number, 4, to any number, 3; then A B must contain four such equal parts, A *a*, as those of which B C contains three, B *b*; and D E must contain four such equal parts, D *d*, as those of which E F contains three, E *e*. Hence A B is to D E as A *a* to D *d* (Theo. 67. Cor.); and B C also is to E F as B *b* to E *e*, or as A *a* to D *d*; consequently A B : D E :: B C : E F. Q. E. D.

Cor. If A B : B C :: D E : E F, then inversely B C : A B :: E F : D E.

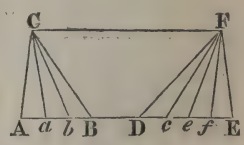
Theorem LXIX.

In any four quantities, A B, B C, D E, E F (see the last figure), *if* A B : B C :: D E : E F, *then* A B ± B C : A B, *or* B C :: D E ± E F : D E *or* E F.

For A B + B C, or A C, is to A B or B C as the number of parts in A C is to the number of equal parts in A B or B C; or as the number of parts in D F is to the number of equal parts in D E or E F, that is, as D F to D E or E F. In the same way it may be shown that A B − B C : A B or B C :: D E − E F : D E or E F; and that A B + B C : A B ∽ B C :: D E + E F : D E ∽ E F. Q. E. D.

Theorem LXX.

Triangles, as A B C, D E F, *between the same parallels*, A E, C F, *or that have the same altitudes, are to each other as their bases*, A B *and* D E.

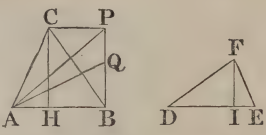


For let A B be to D E as any number, 3, for example, to any other number, as 4; that is, let A B contain three such equal parts, A *a*, *a b*, *b* B, whereof D E contains four, D *c*, *c e*, *e f*, *f* E; and join C *a*, C *b*, F *c*, F *e*, and F *f*. Then the triangles C A *a*, C *a b*, C *b* B, F D *c*, F *c e*, &c. are all equal (Cor. 1. Theo. 33.); and therefore the triangle A B C contains three such equal parts as those of which D F E contains four. Hence the triangle A B C is to the triangle D F E as 3 is to 4, which is the same proportion that their bases have. Q. E. D

Cor. Parallelograms and rectangles between the same parallels, or that have equal altitudes, are to each other as their bases.

Theorem LXXI.

If two triangles, A B C, D E F, *stand on equal bases*, A B, D E, *the triangles are to each other as the perpendiculars*, C H, F I, *drawn from their vertices to their bases.*



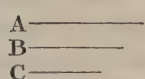
Let B P be perpendicular to A B and equal to C H, and let B Q be equal to F I. Then the triangle A B P is equal to the triangle A B C, and the triangle A B Q to the triangle D F E. But A B P : A B Q :: B P : B Q (Theo. 70.); or A B C : D E F :: C H : F I. Q. E. D.

Cor. 1. Parallelograms on equal bases are to each other as their altitudes.

Cor. 2. Rectangles on equal bases are to each other as their altitudes.

Theorem LXXII.

If four lines, A, B, C, D, *be proportional, that is, if* A : B :: C : D, *the rectangle under the extremes,* A *and* D, *is equal to the rectangle under the means,* B *and* C, *or* A . D = B . C.



For A . D : B . D :: A : B, or C : D; and C : D :: B . C : B . D (Theo. 71. Cor. 2.); whence A . D : B . D :: B . C : B . D; therefore, as A . D and B . C have the same proportion to B . D, A . D and B . C are equal to each other. Q. E. D.

Cor. 1. Since, by the rules of proportion in numbers, when four numbers are proportional, the product of the extremes is equal to the product of the means; and, by this theorem, when four lines are proportional, the rectangle of the extremes is equal to the rectangle of the means; it follows, that the area or space of a rectangle may be represented or expressed by the product of its length multiplied by its breadth. And a square may be represented by the measure of its side multiplied by itself. So that the relations which exist among such products exist also among squares and rectangles.

Cor. 2. When the two means are equal, their rectangle becomes a square; and hence it follows that, when three lines are proportionals, the rectangle of the extremes is equal to the square of the mean.

Theorem LXXIII.

If two rectangles A . D *and* B . C (see the last figure) *are equal, their sides are inversely proportional, or* A : B :: C : D.

For as A . D = B . C, therefore A . D : B . D :: B . C : B . D. But A . D : B . D :: A : B; and B . C : B . D :: C : D (Theo. 71. Cor. 2.); hence A : B :: C : D. Q. E. D.

Cor. If there be three lines, and the rectangle of the two extremes be equal to the square of the mean, these three lines are proportionals.

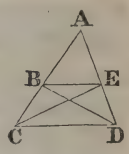
Theorem LXXIV.

If three straight lines, A, B, *and* C, *be proportionals, that is, if* A : B :: B : C, *then* A : C :: A^2 : B^2.

For A : B :: A^2 : A B, and B : C :: B^2 : B . C (Theo. 71. Cor. 2.). Hence, if A : B :: B : C, then A^2 : A . B :: B^2 : B . C; A———— or (Theo. 68.) A^2 : B^2 :: A . B : B . C. But (Theo. 71. B———— Cor. 2.) A . B : B . C :: A : C; therefore A : C :: A^2 : B^2. C———— Q. E. D.

Theorem LXXV.

Any line, as B E, *drawn parallel to* C D, *one of the sides of a triangle* A C D, *divides the other sides* A C, A D *in the same proportion, or so that* A B : A C :: A E : A D.

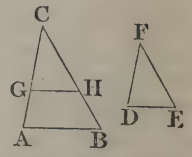


Let C E and B D be joined; then the triangles, B C E, B D E, being on the same base B E, and between the same parallels, are equal (Cor. Theo. 32.); and if to each be added the triangle A B E, the triangles A C E and A B D are also equal, and they therefore have the same proportion to the whole triangle. But the triangle A B D is to the triangle A C D as A B is to A C; and the triangle A C E is to the triangle A C D as A E is to A D (Theo. 70.). Hence A B is to A C as A E is to A D. Q. E. D.

Cor. A B : B C :: A E : E D, and B C : A C :: E D : A D.

Theorem LXXVI.

Equiangular triangles, as A B C, D E F, *have their corresponding sides about the equal angles, as* C *and* F, *in the same proportion, viz.* C A : C B :: F D : F E.



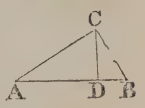
Conceive the point F to be laid on the point C, and the line F D on the line C A, and let the point D fall at G; then as F D coincides with C G, and the angle F is equal to the angle C, the line F E will fall on the line C B. Let the point E fall at H. Now, as the angle F D E, or the angle C G H, is equal to the angle A, the line G H is parallel to the line A B; and hence C A : C B :: C G : C H (Theo. 75.), or :: F D : F E.

In the same way it may be shown that A C : A B :: F D : D E, and that A B : B C :: D E : E F. Q. E. D.

Cor. Equiangular triangles are similar.

Theorem LXXVII.

If A B C *be a triangle, right-angled at* C, *and* C D *be a perpendicular from the right angle* C, *on the hypothenuse* A B, *then* A D : D C :: D C : D B, A B : A C :: A C : A D, and A B : B C :: B C : B D.



For the triangles A B C, A D C, having the common angle A, and the right angles A D C, and A C B equal, are similar (Cor. Theo. 76.); and in like manner may B D C be shown to be similar to A C B.

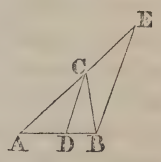
Hence the triangles A B C, A D C, and B D C, are all similar, and consequently A D : C D :: C D : D B, and A B : A C :: A C : A D, and A B : B C :: B C : B D (Theo. 76.). Q. E. D.

Cor. 1. A B . A D = A C², A B . B D = B C², and A D . D B = D C².

Cor. 2. A B . A D + A B . B D = A C² + B C²; or A B² = A C² + B C², another proof of the property demonstrated in Theo. 44.

Theorem LXXVIII.

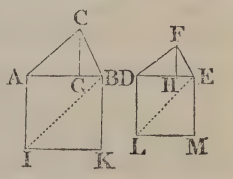
If the angle C, *of the triangle* A B C, *be bisected by the line* C D, *then* A C *is to* C B *as* A D *is to* D B.



Let B E parallel to C D, meet A C produced in E. Then A C : C E :: A D : D B (Theo. 75.). But as the parallel lines D C and B E are cut by the line A C E, the angles E and A C D are equal (Theo. 19); and as the same parallel lines are cut by the line B C, the angles D C B and C B E are equal (Theo. 17.). Hence, as A C D and D C B are equal, E, and C B E are equal, and consequently (Theo. 4.) C E is equal to C B; therefore A C : C B :: A D : D B. Q. E. D.

Theorem LXXIX.

If A B C, D F E *be two similar triangles,* A B *and* D E *sides opposite the equal angles* C *and* F; *the triangle* A B C *is to the triangle* D F E *as the square of* A B *to the square of* D E, or as A B² *to* D E².



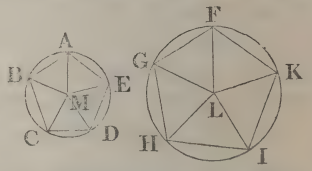
For let A K, D M, be the squares on A B and D E; B I and E L diagonals of these squares; and C G, F H, perpendiculars from C and F upon A B and D E. Then, as the angle C A G is equal to the angle F D H, and the angles A G C, D H F, being right angles, are equal to each other, the angles A C G, D F H, are also equal (Theo. 23. Cor. 1.); and consequently the triangles A C G and D F H are equiangular. Hence A C : D F :: C G : F H (Theo. 76.). But A C : D F :: A B : D E, or :: A I : D L; therefore C G : F H :: A I : D L; or C G : A I :: F H : D L (Theo. 68.). But the triangle

A B C is to the triangle A B I as C G is to A I; and the triangle D E F is to the triangle D L E as F H is to D L (Theo. 71.); therefore the triangle A B C is to the triangle A B I as the triangle D F E to the triangle D L E; or the triangle A B C is to the triangle D F E as twice the triangle A B I is to twice the triangle D L E, or as A K is to D M; that is, as the square of A B is to the square of D E. Q. E. D.

Theorem LXXX.

If A B C D E *be an equilateral polygon inscribed in the circle whose centre is* M, *and* F G H I K *an equilateral polygon of a like number of sides inscribed in the circle whose centre is* L, *the perimeter of the polygon* A B C D E *is to the perimeter of the polygon* F G H I K, *as the radius* A M *to the radius* F L.

For join M to A, B, C, D, and E, and L to F, G, H, I, and K, then the triangles A M B, B M C, &c. being mutually identical; and the triangles F L G, G L H, &c. being also mutually identical (Theo. 5.), the angles A M B, F L G, are like parts of four right angles, and they are consequently equal. Therefore, as the triangles are isosceles, the angles M A B, M B A, are respectively equal to the angles L F G, L G F. Whence the triangles are equiangular; and therefore M A : F L :: A B : F G (Theo. 76.), or :: the perimeter A B C D E A : the perimeter F G H I K F (Theo. 67.), since the perimeters are like multiples of A B and F G. Q. E. D.

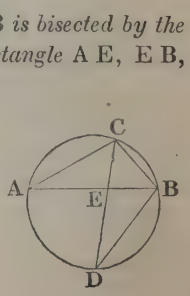


Cor. If we conceive the sides of the polygons to be indefinitely small, and their number to be indefinitely great, the property which has here been proved of equilateral polygons inscribed in a circle, will become a property of the circles themselves; for the polygons will then coincide with the circumferences of the circles. Hence the circumferences of circles are to each other as their radii, or as their diameters.

Theorem LXXXI.

If A B C *be a triangle, one of whose angles* A C B *is bisected by the line* C E; *the rectangle* A C, C B *is equal to the rectangle* A E, E B, *together with the square of* C E.

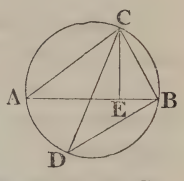
Let A C B D, be a circle circumscribing the triangle, and let C E, produced, meet the circumference in D, and join D B. Then the angles C A E and C D B are equal, as they are in the same segment (Cor. 2. Theo. 52.); and the angles A C E and D C B are equal also, because the line



C E D bisects the angle A C B. Hence the angle A E C is equal to the angle D B C (Theo. 23. Cor. 1.), and the triangles A E C and D B C are similar. Therefore A C : C E :: C D : B C (Theo. 76.); and consequently A C . C B = C E . C D (Theo. 72.). But C E . C D = C E² + C E . E D (Theo. 40.), and C E . E D = A E . E B (Cor. 1. Theo. 66.). Hence A C . C B = A E . E B + C E². Q. E. D.

Theorem LXXXII.

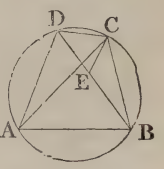
If C D *be a diameter of a circle, circumscribing the triangle* A B C, *and* C E *a perpendicular from* C *on the opposite side* A B; *the rectangle* A C . C B *is equal to the rectangle* D C . C E.



Join D B. Then the angles C A E and C D B are equal, as they are in the same segment (Cor. 2. Theo. 52.), and the angle C B D, in a semicircle, being (Cor. 3. Theo. 52.) a right angle, is equal to the right angle C E A; therefore the angles A C E and D C B are equal (Theo. 23. Cor. 1.), and the triangles A E C and D C B are similar. Hence A C : C E :: D C : C B (Theo. 76.); and consequently A C . C B = C D . C E (Theo. 72.). Q. E. D.

Theorem LXXXIII.

If A B C D *be a quadrilateral inscribed in a circle, the rectangle* A C . B D *is equal to the two rectangles* A D . B C, *and* A B . D C.

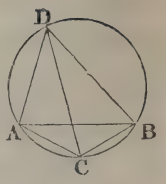


From C let C E be drawn, making the angle D C E equal to the angle A C B. Then as the angles C D E, C A B, standing on the same segments, are equal (Cor. 2. Theo. 52.), the angles D E C and A B C are equal (Theo. 23. Cor. 1.). Hence the triangles D E C and A B C are similar, and consequently A B : A C :: D E : D C (Theo. 76.). Whence A B . D C = A C . D E (Theo. 72.). Now, if from the equal angles D C E and A C B, the common angle A C E be taken away, the remaining angles D C A and E C B will be equal; and the angles E B C and D A C standing on the same segment are equal (Cor. 2. Theo. 52.); therefore the angles A D C and B E C are equal (Theo. 23. Cor. 1.); and, consequently, A D : A C :: B E : B C (Theo. 76.), or A D . B C = A C . B E (Theo. 72.). But it has been shown, that A B . D C = A C . D E, therefore A B . D C + A D . B C = A C . D E + A C . B E = A C . D B (Theo. 39.). Q. E. D.

Theorem LXXXIV.

Let A B, *an arc of a circle, be bisected in* C; *draw the chords* A B, A C, *and* B C; *and to any point,* D *in the circumference, draw* A D, B D, *and* C D; *then* A C : A B :: C D : A D + D B.

For (Theo. 83.) $AB.CD = BC.AD + AC.DB = AC.AD + AC.DB =$ (Theo. 39.) $AC.\overline{AD + DB}$. Hence (Theo. 73.) $AC : AB :: CD : \overline{AD + DB}$.



ON THE INTERSECTION OF PLANES.

Definitions.

1. A straight line is perpendicular to a plane when it makes right angles with every straight line which it meets in that plane.

2. Two planes are perpendicular to each other when any straight line drawn in one of the planes, perpendicular to their common section, is perpendicular to the other plane.

3. If two planes cut each other, and from any point in the line of their common section, two straight lines be drawn, at right angles to that line, one in the one plane, and the other in the other plane, the angle contained by these two lines is the angle made by the planes.

4. A straight line is parallel to a plane when it does not meet the plane, though produced ever so far.

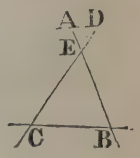
5. Planes are parallel to each other when they do not meet, though produced ever so far.

6. A solid angle is one which is formed by the meeting, in one point, of more than two plane angles, which are not in the same plane with each other.

Theorem LXXXV.

If any three straight lines, A B, C D, C B, *meet one another, as in* C, B, *and* E, *they are in one plane.*

For conceive a plane passing through B C to revolve about that line till it pass through the point E. Then because the points E and C are in that plane, the line E C is in it; and, for the same reason, the line E B is in it; and B C is in it, by hypothesis. Hence the lines A B, C E, and B C are all in one plane.

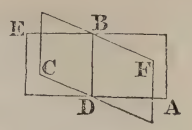


Cor. Any two straight lines which meet each other are in one plane; and any three points whatever are in one plane.

Theorem LXXXVI.

If two planes, as A E, C F *cut one another, the line of their common section is a straight line.*

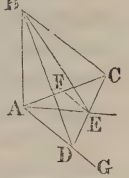
For let B and D, any two points in the line of their common section, be joined by the straight line B D; then because the points B and D are both in the plane A E, the whole line B D is in that plane; and, for the same reason, B D is in the plane C F. The straight line B D is therefore common to both planes; and it is therefore the line of their common section.



Theorem LXXXVII.

If a straight line, as A B, *stand at right angles to each of two other straight lines, as* A C, A G, *at* A, *their point of meeting;* A B *is also at right angles to the plane passing through* A C, A G.

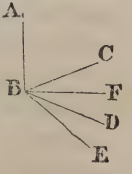
For through A, in the plane passing through A G and A C, draw any line A E; and from any point E in that line draw E F parallel to A G, meeting A C in F. Make F C equal to A F; join C E and produce it till it meet A G in D; and join B D, B E, and B C. Then as F E is parallel to A D, C F : F A :: C E : E D (Theo. 75.); and as C F is equal to F A, C E is equal to E D. Therefore C A D and C B D are triangles, whose bases are bisected in E; and hence (Theo. 49.) $DA^2+AC^2=2DE^2+2EA^2$; to each of these equals add $2AB^2$, and we have $AD^2+AB^2+AC^2+AB^2=2DE^2+2EA^2+2AB^2$. But $AD^2+AB^2=BD^2$ and $AC^2+AB^2=BC^2$; and $BD^2+BC^2=2DE^2+2EB^2$. Hence, $2DE^2+2EB^2=2DE^2+2EA^2+2AB^2$; and omitting $2DE^2$ from each, and taking the half of each remainder, we have $EB^2=EA^2+AB^2$; whence the angle B A E is a right angle. Hence as B A is perpendicular to any line which it meets in the plane G A C, it is perpendicular to every line which it meets in that plane, and therefore it is perpendicular to the plane itself.



Theorem LXXXVIII.

If a straight line, as A B, *stand at right angles to each of three straight lines, as* B C, B D, B E, *at* B, *their point of meeting, these three straight lines are all in one plane.*

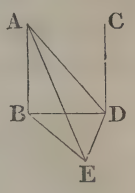
If not, let B D and B E, if possible, be in one plane, and B C above it; and let the plane passing through A B and B C meet the plane in which B D and B E are, in the straight line B F. Then because A B is at right angles to B D and B E at their point of meeting, it is also at right angles to B F, which it meets in the plane of B D and B E. But A B is also by hypothesis at right angles to B C, and therefore the angles A B C, A B F, in the same planes, are equal to each other, which is impossible. B C is therefore not out of the plane of B E and B D, therefore the three lines B C, B D, and B E, are all in one plane.



Theorem LXXXIX.

If two straight lines, as A B, C D, *be at right angles to the same plane, as* B D E, A B *is parallel to* C D.

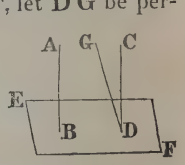
In the plane B D E draw D E at right angles to B D, take any point E in it, and join E A, E B, and A D. Then the square of E A is equal to the squares of E B and B A; and the square of E B is equal to the squares of E D and D B (Theo. 44.). Hence the square of E A is equal to the squares of E D, D B, and B A; and as the squares of B D and B A are equal to the square of D A, the square of E A is equal to the sum of the squares of E D and D A; and consequently E D A is a right angle. E D being therefore at right angles to B D, A D, and C D, these three lines are all in one plane (Theo. 88.). But A D and B D are in the same plane with A B (Theo. 85.). Hence A B and C D are in one plane; and as each of the angles A B D, C D B is a right angle, A B is parallel to C D (Cor. 1. Theo. 19.).



Theorem XC.

If A B, *one of two parallel straight lines, be at right angles to a plane, as* E F, *the other* C D *is also at right angles to the same plane.*

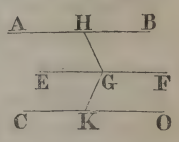
For if C D be not perpendicular to the plane E F, let D G be perpendicular to it. Then as A B and D G are perpendicular to the same plane, they are parallel to each other (Theo. 89.). Hence D C and D G drawn through the same point are parallel to the same straight line, which is impossible. Therefore no line drawn through D, except D C, is at right angles to the plane E F; and D C is consequently at right angles to it.



Theorem XCI.

If A B, C O, *any two lines, be each parallel to another line* E F, *though not all three in the same plane,* A B *and* C O *are parallel to each other.*

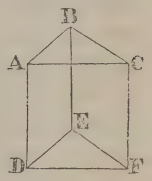
From any point G in E F, let G H be drawn, at right angles to E F, in the plane passing through A B and E F; and in the plane passing through E F and C O let G K be drawn also at right angles to E F. Then as E F is perpendicular to G H and G K, it is perpendicular to G H K, the plane passing through them (Theo. 87.). And as E F is parallel to A B, A B is also at right angles to the plane G H K (Theo. 90.). For the same reason C O is at right angles to the plane G H K, and hence A B and C O being at right angles to the same plane, are parallel to each other (Theo. 89.).



Theorem XCII.

If two straight lines, as A B, B C, *which meet one another, be parallel to two other straight lines, as* D E, E F, *that meet one another, but are not in the same plane with* A B, B C ; *the angle* A B C *is equal to the angle* D E F.

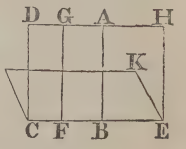
Take B A, B C, E D, E F, all equal to one another, and join A D, C F, B E, A C, and D F. Then as A B is equal and parallel to D E, A D is equal and parallel to B E (Theo. 30.). For the same reason C F is equal and parallel to B E. Hence A D and C F being equal and parallel to the same straight line are equal and parallel to each other (Theo. 91.); and consequently A C and D F are equal and parallel (Theo. 30.). Therefore the triangles A B C, D E F, having A B and B C equal respectively to D E and E F, and A C equal to D F, have also the angles A B C and D E F equal (Theo. 5.).



Theorem XCIII.

If any straight line, A B, *be at right angles to a plane,* C K, *any plane,* D E, *passing through* A B, *is at right angles to the plane* C K.

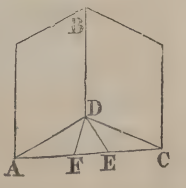
For let C E be the common section of the planes D E, C K; and from any point F in C E, draw F G in the plane D E, at right angles to C E. Then as A B is perpendicular to the plane C K, it is perpendicular to C E meeting it in that plane; therefore A B F is a right angle; and as G F B is also a right angle, G F is parallel to A B (Cor. 1. Theo. 19.). Hence as A B is at right angles to the plane C K, F G is at right angles to the same plane (Theo. 90.); and consequently the plane D E is at right angles to the plane C K (Def. 2. p. 52); and thus may any other plane passing through A B be shewn to be at right angles to the plane C K.



Theorem XCIV.

If each of two planes A B, B C *be perpendicular to a third plane* A D C, *the common section* B D *of the first two planes, is also perpendicular to the third plane.*

For from D in the plane A D C draw D E perpendicular to A D, and D F perpendicular to D C. Then as D E is at right angles to D A, the common section of the planes A B and A D C, and those planes are at right angles to each other, therefore E D is at right angles to the plane A D B, and consequently to D B. For the same reason D F is at

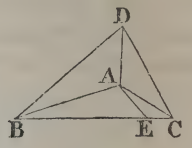


right angles to D B; and hence as B D is at right angles to both D F and D E at their point of meeting, it is at right angles to the plane A D C in which these lines are (Theo. 87.).

Theorem XCV.

If a solid angle as A, *be contained by three plane angles, as* B A C, C A D, D A B, *any two of these plane angles are greater than the third.*

If the angles B A C, C A D, D A B, be all equal, it is evident that any two of them are greater than the third. If they are not all equal, let B A C be the greatest of them; and in the plane B A C, draw the line A E, making the angle B A E equal to the angle B A D; make A E equal to A D, and through E draw any straight B E C, cutting A B and A C in B and C, and join B D, C D. Then as D A is equal to A E, the angle B A D to the angle B A E, and the side B A common to the two triangles B A D and B A E, their bases B D and B E are equal (Theo. 1.); and consequently E C is the difference of B C and B D, and it is less than D C the other side of the triangle B D C (Theo. 16.). Now D A and A E are equal, and A C common to the triangles D A C and E A C, but D C the base of the triangle D A C is greater than E C the base of the triangle E A C; therefore the angle D A C is greater than the angle E A C (Theo. 14.). But D A B and E A B are equal by construction, whence D A B and D A C together are greater than B A E and E A C together, or than B A C. And as the least two together exceed the greatest, it is evident that any two of them together are greater than the third.

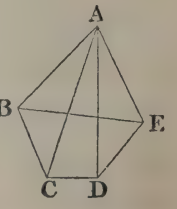


Cor. E A C being less than D A C, if a solid angle be contained by three plane angles, the difference of any two of them is less than the third.

Theorem XCVI.

If A *be a solid angle contained in any number of plane angles* B A C, C A D, D A E, E A B, *these plane angles together are less than four right angles.*

Let the planes which contain the solid angle at A be cut by another plane, and let the section of them by that plane be the rectilineal figure B C D E. Then the solid angle at B being contained by three plane angles, any two of these angles, as A B E, A B C, are greater than the third E B C (Theo. 95.). For the same reason the angles A C D and A C B are together greater than B C D; A D C, and A D E greater than C D E; and A E D, and A E B greater



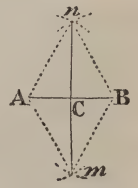
than D E B. Hence the angles at the bases of the triangles, which have their common vertex at A, are greater than the interior angles of the rectilineal figure B C D E. But all the angles of the triangles B A C, C A D, D A E, B A E, are equal to twice as many right angles as there are triangles, or as there are sides in the figure B C D E; and the interior angles of that figure, together with four right angles, are also equal to twice as many right angles as the figure has sides (Theo. 24.). Therefore all the angles of the triangles are equal to all the angles of the figure, together with four right angles. And as all the angles at the base of the triangles are greater than all the interior angles of the figure, the remaining angles of the triangles, or those which contain the solid angle A, are less than four right angles.

GEOMETRICAL PROBLEMS.

Problem I.

To bisect a given straight line A B.

From the points A and B, as centres, with any distance greater than half A B, describe arcs cutting each other in *n* and *m*. Join *n m*, and the point C where it cuts A B will be the middle of the line required.



For join A *n*, A *m*, B *n*, and B *m*; then because A *n* and A *m* are respectively equal to B *n* and B *m*, and *n m* is common to both the triangles, A *m n*, and B *m n*, the angles A *n m* and B *n m*, or A *n* C and B *n* C are equal. And hence as A *n* and B *n* are equal, and *n* C common to both triangles, the sides, A C and B C, are equal; or A B is bisected in C.

Problem II.

To bisect a given angle A B C.

From the angular point B, with any radius, describe the arc A C, and from the points A and C, with the same, or any other radius, describe arcs cutting each other in *n*. Join B *n*, and the line B *n* bisects the angle A B C.

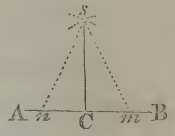
For join A *n*, C *n*, then as A B is equal to B C, A *n* to C *n*, and B *n* is common to both the triangles A B *n* and C B *n*; therefore the angle A B *n* is equal o the angle C B *n*; or A B C is bisected by B *n*.

Problem III.

From a given point C *in a given line* A B *to draw a perpendicular.*

1st. When the point is near the middle of the line.

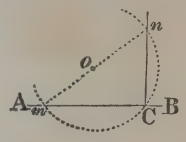
On each side of the point C take any two equal distances C *n*, C *m*; and from *n* and *m* with any radius greater than C *n* or C *m*, describe arcs cutting each other in *s*. Through *s* and C draw the line *s* C, and it will be the required perpendicular.



For join *s m*, *s n*; then as these two lines are equal, *n* C equal to *m* C, and C *s* common to the triangles *n* C *s*, *m* C *s*, the angles *m* C *s* and *n* C *s* are equal; and therefore *s* C is perpendicular to A B.

2d. When the point is at or near the end of the line.

Take any point *o* as a centre, and with the radius *o* C describe an arc *m* C *n*, cutting A B in *m* and C. Through *m* and *o* draw the line *m o n*, cutting the arc in *n*. Join *n* C, and it is the required perpendicular.

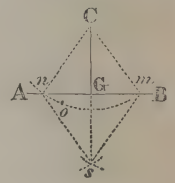


For the angle *m* C *n* being an angle in a semicircle, is a right angle, and therefore *n* C is perpendicular to A B.

Problem IV.

From a given point C *out of a given line* A B, *to draw a line perpendicular to* A B.

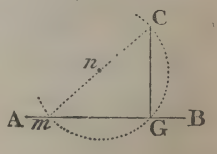
1st. When the given point is nearly opposite the middle of the line. Take any point *o* on the other side of the line A B, and from the centre C with the radius C *o* describe an arc *n o m* cutting A B in *n* and *m*. From *n*, *m*, with any radius greater than half *m n*, describe arcs cutting each other in *s*. Through the points C, *s*, draw the line C G *s*, and C G will be the perpendicular required.



For let *n* C, *n s*, *m* C, *m s*, be joined; then it may be shewn as in the demonstration of Prob. I. that the angles *n* G C and *m* G C are equal, and C G is consequently perpendicular to A B.

2d. When the point is nearly opposite the end of the line.

To any point *m* in the line A B draw the line C *m*, and bisect it in the point *n*. From *n* with the radius *n m* or *n* C describe the arc C G *m* cutting A B in G. Through C and G draw the line C G, and it is the perpendicular required.

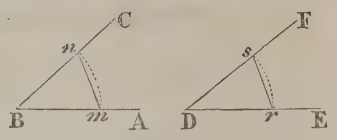


For *m* G C being an angle in a semicircle is a right angle, therefore C G is perpendicular to A B.

Problem V.

At a given point D *in a given line* D E *to make an angle equal to a given angle* A B C.

From B as a centre with any radius describe the arc *n m* cutting B A, B C in the points *m*, *n*; and from D with the same radius describe the arc *r s*. Take the distance *m n* and apply it to the arc *r s* from *r* or *s*. Through the points D, *s*, draw the line D F, then the angle E D F is equal to the angle A B C.



For let *m*, *n* and *s*, *r* be joined; then the triangles B *n m* and D *s r* having B *n* and B *m* equal to D *s* and D *r*, and *n m* equal to *s r*, have the angles B and D, are equal.

Problem VI.

At any point B *in a given line* B A (*see the last figure*) *to make an angle of a given number of degrees, or points of the compass.*

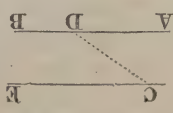
With the centre B and the chord of 60 degrees as a radius, taken from any line of chords, describe the arc *m*, *n*; and from the same line of chords, or from a line of rhombs or points adapted to the same radius, take the chord of the proposed arc; with which as a radius from the centre *m*, cross *m n* in *n*, and join B *n*; then the angle *n* B *m* is the required angle.

If the angle is too great for its chord to be obtained at once, take the chord of its half, and laying it from *m* to *n*, repeat it again from *n* on the arc *m n* produced, and joining the second point to B, the required angle will be obtained.

Problem VII.

Through a given point C, *to draw a line parallel to a given line* A B.

From C to A B draw any line C D; then through C draw the line C E, making the angle D C E equal to the angle C D A; and C E is the required line.



For the alternate angles A D C and D C E being equal, the lines A D and C E are parallel.

Note. This problem is most conveniently performed by means of a parallel ruler.

Problem VIII.

To draw a line parallel to a given line A B, *at a distance from it equal to another given line* C D.

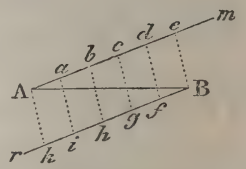
At any point E in A B, erect the perpendicular E F, and make it equal to C D. Through the point F draw F G parallel to A B by the last problem; then F G is the required line.

For F G is parallel to A B by construction; and F E, its distance from A B, is equal to the given line C D.

Problem IX.

To divide a given line A B *into any proposed number of equal parts.*

From A, one end of the given line, draw the line A *m* making any angle with A B; and from B, the other end, draw B *r* parallel to A *m*. In each of these lines, beginning at A and B, set off as many equal parts A *a*, *a b*, *b c*, &c. and B *f*, *f g*, *g h*, &c. as A B is to be divided into. Join the points B *e*, *d f*, *c g*, &c. and these lines will divide A B as required.



For as *d e* is equal and parallel to B *f*, B *e* and *d f* are parallel; and in the same manner may *c g*, *b h*, and *a i* be shewn to be parallel to B *e*. Hence the parts into which A B is divided are proportional to the corresponding parts of A *e*; and as the parts of A *e* are equal to each other, the parts of A B are also equal to each other.

Problem X.

To find the centre of a given circle A B C.

Draw any chord A B, and bisect it with the perpendicular C D. Bisect C D in O, and O is the centre required.

For if the centre is in the line C D it must be in O, that point in the chord which is equally distant from its extremities. If, however, the centre is not in C D, let it be in F any point out of the line; and join F E, F A, and F B. Then will A F be equal to F B, A E to E B, and E F common to the triangles A E F and B E F; the angles A E F and B E F will therefore be equal, and consequently each of them will be a right angle. Hence the angles C E B and F E B will be equal, the less to the greater, which is impossible. The centre of the circle is therefore *in* the line C D, and it is consequently in the point O.

Problem XI.

To describe the circumference of a circle through three given points A B C.

Join A C and B C, and bisect these lines with the perpendiculars D O and E O, and from the point O with the distance O A, O B, or O C, describe the circle A B C, and it will be the circle required.

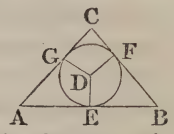
For as A D and D O are respectively equal to C D and D O, and the included angles A D O and C D O are equal, A O is equal to C O; and for a like reason B O is equal to C O. Hence O is the centre of a circle passing through A, B, and C.

Remark. By this problem a circle may be described about a triangle.

Problem XII.

To inscribe a circle in a given triangle A B C.

Bisect any two of the angles, as A and B, and the bisecting lines, A D and D B, will meet in D, the centre of the circle.



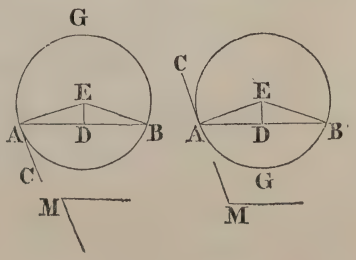
For from D draw D E, D F, and D G, perpendiculars to A B, B C, and A C. Then, as the angles D A G and D A E, D G A and D E A are equal, the angles A D G and A D E are also equal; and as A D is adjacent to the equal angles in each triangle, the triangles are identical, and therefore D E and D G are equal; and thus also may D F be shewn to be equal to D E or D G; and consequently, as the angles at E, F, and G, are right angles, a circle described from D, with the distance D E, D F, or D G, will touch A B, B C, and A C, the sides of the triangle; and the circle is therefore inscribed in the triangle.

Note. The reader is requested to join D to A, B, and C.

Problem XIII.

On a given line A B *to describe the segment of a circle, which will contain an angle equal to a given angle, as* M.

From A draw A C, making the angle C A B equal to the given angle M. Bisect A B with the perpendicular D E; and draw A E perpendicular to A C, meeting D E in E; then from the centre E, with the radius A E or E B, describe a circle, and the



segment of it A G B, alternate to the angle C A B, is the segment required.

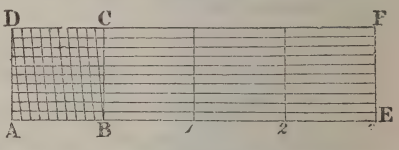
For as A D is equal to D B, and the angles A D E and B D E are equal, and D E common to the triangles A D E and B D E; therefore A E and B E are equal. And as A E is perpendicular to A C, therefore A C is a tangent to the circle of which A B is a chord; and hence the angle C A B is equal to any angle in the alternate segment, A G B.

Remark. If the given angle is a right angle, the required segment is a semicircle described on the given line.

Problem XIV.

To make a plain diagonal, decimal scale.

Take A B, of the length proposed for the longest division of the scale, and draw ten lines parallel to it, and equidistant from each other; draw A D and B C perpendicular to A B; and divide A B and C D each into ten equal parts. Join B to the first division in C D, the first division on A B to the second on C D, &c. In A B produced take B 1, 1 2, &c. each equal to A B; and from the points 1, 2, &c. draw lines parallel to B C, meeting C D produced; and the scale is completed.



For A B is divided into ten equal parts, and the oblique lines drawn from A B to C D subdivide the divisions of A B again into tenths.

EXAMPLES FOR EXERCISE IN GEOMETRICAL INVESTIGATION.

1. From two given points, to draw two equal straight lines, which shall meet in the same point, in a line given in position.

2. From two given points on the same side of a line, given in position, to draw two lines which shall meet in that line, and equal angles with it.

3. If two chords intersect at right angles within a circle, the sum of the squares of their segments is equal to the square of the diameter.

4. Of all straight lines which can be drawn from two given points to meet on the convex circumference of a given circle, the sum of those two which make equal angles with the tangent at the point of concourse, is the least.

5. If a circle be described on the radius of another circle, any

straight line drawn from the point where they meet to the outer circumference, is bisected by the interior one.

6. From two given points on the same side of a line given in position, to draw two straight lines which shall contain a given angle, and be terminated in that line.

7. If from any point in the diameter of a circle lines be drawn to the extremities of any chord parallel to that diameter, the sum of the squares of those lines is equal to the sum of the squares of the segments of the diameter.

8. If a common tangent be drawn to any number of circles which touch each other internally, and, from any point in this tangent as a centre, a circle be described cutting the others, and from this centre lines be drawn through the intersections of the circles respectively; the segments of them within each circle will be equal.

9. Triangles which have one angle equal in each, and the sides about the equal angles in the same proportion, are equiangular triangles.

10. If from any two points in the circumference of a circle there be drawn two straight lines to a point in a tangent to that circle, they will make the greatest angle when drawn to the point of contact.

11. If one chord in a circle bisect another, and tangents drawn from the extremities of each be produced to meet, the line joining their points of intersection will be parallel to the bisected chord.

12. If two circles cut each other, the greatest line that can be drawn through the point of intersection, is that which is parallel to the line joining their centres.

13. If the points of bisection of the sides of a given triangle be joined, the triangle, so formed, will be one-fourth of the given triangle.

14. The difference of the angles at the base of any triangle, is double the angle contained by a line drawn from the vertex perpendicular to the base, and another bisecting the angle at the vertex.

15. If the three sides of a triangle be bisected, the perpendiculars drawn to the sides, at the three points of bisection, will meet in the same point.

16. If from the three angles of a triangle lines be drawn to the points of bisection of the opposite sides, these lines intersect each other in the same point.

17. The three straight lines which bisect the angles of a triangle meet in the same point.

18. The two triangles, formed by drawing straight lines from any point within a parallelogram to the extremities of two opposite sides, are, together, half the parallelogram.

19. The figure formed by joining the points of bisection of the sides of any trapezium, is a parallelogram.

20. If squares be described on the three sides of a right-angled triangle,

and the extremities of the adjacent sides be joined; the triangles so formed, are equal to the given triangle, and to each other.

21. If squares be described on the hypothenuse and sides of a right-angled triangle, and the extremities of the sides of the former and the adjacent sides of the others be joined, the sum of the squares of the lines joining them will be equal to five times the square of the hypothenuse.

22. The vertical angle of an oblique-angled triangle inscribed in a circle, is greater or less than a right angle, by the angle contained between the base, and the diameter drawn from the extremity of the base.

23. A straight line drawn from the vertex of an equilateral triangle, inscribed in a circle to any point in the opposite circumference, is equal to the two lines together, which are drawn from the extremities of the base to the same point.

24. The straight line bisecting any angle of a triangle inscribed in a given circle, cuts the circumference in a point, which is equidistant from the extremities of the sides opposite to the bisected angle, and from the centre of a circle inscribed in the triangle.

25. In any triangle, if perpendiculars be drawn from the angles to the opposite sides, they will all meet in a point.

26. If from the centre of a circle a line be drawn to any point in the chord of an arc, the square of that line, together with the rectangle contained by the segments of the chord, will be equal to the square described on the radius.

27. If two points be taken in the diameter of a circle, equidistant from the centre, the sum of the squares of the two lines drawn from these points to any point in the circumference, will be always the same.

28. If on the diameter of a semicircle, two equal circles be described, and in the space included by the three circumferences a circle be inscribed, its diameter will be two-thirds of the diameter of either of the equal circles.

ELEMENTARY PRINCIPLES

OF

PLANE TRIGONOMETRY.

PLANE TRIGONOMETRY is that branch of Mathematics by which, if certain parts of a plane triangle be given, the other parts may be computed.

As the *sides* and *angles* of triangles are quantities of different kinds, they cannot be *compared* with each other; but the relation between the sides and the *magnitude* of the angles may be discovered by comparing the sides with certain lines drawn in and about a *circle*, on which lines the arcs of the circle which measure the angles of the triangles depend.

DEFINITIONS.

1. If two lines meet in the centre of a circle, the arc of the circumference intercepted between them is called the *measure* of the angle which they contain.

2. If the circumference of a circle be divided into 360 equal parts, each of these parts is called a *degree;* if a *degree* be divided into 60 equal parts, each of these parts is called a *minute;* and if a minute be divided into 60 equal parts, each of these parts is called a *second*, &c. And whatever number of degrees, minutes, seconds, &c. are contained in any arc, the angle at the centre, which that arc measures, contains the same number of degrees, minutes, seconds, &c.

Cor. 1. Any arc is to the whole circumference of which it is a part as the number of degrees, &c. contained in the arc, is to 360 degrees; and any angle is to four right angles in the same proportion.

Cor. 2. Whatever be the radii with which the arcs are described which measure any angle, the arcs contain the same number of degrees, &c. For the arcs are like parts of 360 degrees.

Def. 3. Degrees, minutes, seconds, &c. are usually designated by the marks: °, ′, ″, ‴, &c. Thus 37° 14′ 20″ 38‴ is 37 degrees, 14 minutes, 20 seconds, and 38 thirds.

4. Two arcs, whose sum is equal to a semicircle, or two angles whose sum is equal to two right angles, are called *supplements* of each other.

5. Two arcs, whose sum or difference is a quadrant, or two angles whose sum or difference is a right angle, are called *complements* to each other.

6. The *sine* of an arc is a perpendicular let fall from one of its extremities upon the diameter which passes through the other extremity.

7. The *versed sine* of an arc is that portion of the diameter intercepted between the sine and the circumference.

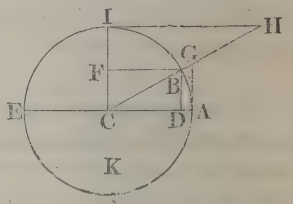
8. The *suversed sine* of an arc is the versed sine of its supplement.

9. The *tangent* of an arc is a perpendicular to the diameter at one extremity of the arc, and terminated by the diameter produced, which passes through the other extremity.

10. The *secant* of an arc is the straight line drawn from the centre to the termination of the tangent.

Remark. The *sine*, *tangent*, *secant*, &c. of the *complement* of an arc, are usually termed the *cosine*, *cotangent*, and *cosecant* of that arc.

To illustrate the above definitions, let A E be the diameter of a circle A I E K; C I a perpendicular radius from the centre C; A G and I H perpendiculars to A E and C I, meeting C H drawn from the centre in G and H. From B, where C H meets the circumference, draw B D and B F perpendicular to A C and C I. Then the arcs A B and B I E, and the angles A C B and B C E, are *supplements* of each other. The arcs A B and B I, the arcs E I B and B I, the angles A C B and B C I, and the angles E C B and B C I, are respectively *complements* of each other. B D is the *sine* of the arc A B, or of the arc E I B; and it is also considered as the *sine* of either of the *supplement* angles, A C B or B C E, to the radius A C. A G is the *tangent*, and C G the *secant* of the *arcs* or the *angles* of which B D is the *sine*. A D is the *versed sine* of the arc A B, and E D its *suversed sine*. B F or C D is the *sine* of I B, or the *cosine* of A B; I H is the *tangent*, and C H the *secant* of I B; or I H is the *cotangent*, and C H the *cosecant* of A B. I F is the *versed sine* of I B, or the *coversed* sine of A B. And in all cases the *sine*, *cosine*, *tangent*, &c. of any arc, is called also the *sine*, *cosine*, *tangent*, &c. of the angle measured by that arc.



For the sake of brevity, these technical terms in trigonometry are usually contracted as follows:—

Thus for *Sine* of an arc, as A B, is put		*Sin.* A B.
Cosine	do.	*Cos.* A B.
Tangent	do.	*Tan.* A B.
Cotangent	do.	*Cot.* A B.

For *Secant* of an arc, as A B, is put *Sec.* A B.

Cosecant	do.	*Cosec.* A B.
Versed sine	do.	*Vers.* A B.
Suversed sine	do.	*Suvers.* A B.
Coversed sine	do.	*Covers.* A B.

From the above definitions we deduce the following obvious consequences: viz.

1st, When an arc vanishes, or becomes nothing, its sine, tangent, and versed sine, are nothing also; and its secant and cosine are each equal to the radius.

2d, The sine and the versed sine of a quadrant are each equal to the radius, its cosine is nothing, and its secant and tangent are infinite.

3d, The chord of an arc is twice the sine of half the arc.

4th, The radius B C, the sine B D, and the cosine C D, form a right-angled triangle C B D. The secant C G, the tangent G A, and the radius C A, form also a right-angled triangle C G A, similar to C B D; and the cosecant H C, the radius C I, and the cotangent I H, form another right-angled triangle similar to C B D or C G A.

Hence $CD^2 + DB^2 = CB^2$; or $\cos^2 + \sin^2 = \text{rad}^2$.

$CA^2 + AG^2 = CG^2$; or $\text{rad}^2 + \tan^2 = \sec^2$.

$CI^2 + IH^2 = CH^2$; or $\text{rad}^2 + \cot^2 = \text{cosec}^2$.

And CD : DB :: CA : AG; or cos : sin :: rad : tan; or tan . cos = rad . sin; or $\tan = \frac{\text{rad} \cdot \sin}{\cos} = \frac{\sin}{\cos}$, when the numerical value of radius is one, or unity.

CF : FB :: CI : IH; or sin : cos :: rad : cot; or cot . sin = rad . cos; or $\cot = \frac{\text{rad} \cdot \cos}{\sin} = \frac{\cos}{\sin}$, when rad is unity.

CD : CB :: CA : CG; or cos : rad :: rad : sec; or cos . sec = rad^2; or $\sec = \frac{\text{rad}^2}{\cos} = \frac{1}{\cos}$, when rad is unity.

CF : CB :: CI : CH; or sin : rad :: rad : cosec; or sin . cosec = rad^2; or $\text{cosec} = \frac{\text{rad}^2}{\sin} = \frac{1}{\sin}$, when rad is unity.

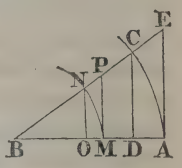
GA : AC :: CI : IH; or tan : rad :: rad : cot; or tan . cot = rad^2; whence $\cot = \frac{\text{rad}^2}{\tan}$; and $\tan = \frac{\text{rad}^2}{\cot}$; or $\tan = \frac{1}{\cot}$, and $\cot = \frac{1}{\tan}$, when rad is unity.

5th, If A and B represent any two arcs, it appears from the last corollary that tan A . cot A = tan B . cot B. Whence cot A : cot B :: tan B : tan A. And in a similar way we deduce cos A : sec B :: cos B : sec A; and sin A : cosec B :: sin B : cosec A.

6th, As A D. D E = D B², we have vers. suvers = sin².

7th, The sine, tangent, &c. of an arc, which is the measure of any given angle, as A B C, is to the sine, tangent, &c. of any other arc, by which the same angle A B C may be measured, as the radius of the first arc to the radius of the second.

Let A C and M N each measure the angle B; C D being the sine, D A the versed sine, A E the tangent, and B E the secant of the arc A C; N O, O M, M P and B P the sine, versed sine, tangent, and secant of the arc M N. Then as O N, M P, D C, and A E, are parallel, we have C D : N O : : rad B C : rad B N; A E : M P : :, or B E : B P : : rad B A : rad B M: and B C : B D : : B N : B O; or B A : B D : : B M : B O. Hence B A : B A − B D : : B M : B M − B O; or B A : A D : : B M : M O; or B A : B M : : A D : M O.



8th, It is often convenient in trigonometrical investigations, to use *sines*, *tangents*, &c. to the arcs of a circle whose radius is unity, as the resulting expressions are of a less complicated form. But such expressions may easily be adapted to any other radius. For, in the last figure, if B C = r, B N = 1, and D C = sine to radius r; then B C (r) : C D (sin) : : B N (1) : N O = $\frac{\sin}{r}$, the corresponding sine to radius unity.

Hence, when any formula has been investigated on the supposition that radius is unity, the formula may be adapted to any other radius r, by substituting $\frac{\sin}{r}$, $\frac{\tan}{r}$, $\frac{\sec}{r}$, &c. for sine, tan, sec, &c. in the given expression.

The numerical values of the sines, tangents, &c. of arcs, computed to a given radius, exhibit also the ratios of the sines, tangents, &c. of those arcs, to any other radius. A table containing such numbers is called a table of *natural* sines, tangents, &c.; and a table exhibiting the logarithms of those numbers is called a table of *logarithmic* sines, tangents, &c.

Such logarithmic tables are generally computed to the large radius, 10000000000, that the logarithm of the smallest sine, tangent, &c. likely to be required in computation may not have a negative index. The logarithm of the radius in such tables is evidently 10, and the logarithm of rad² is 20, and the logarithmic sine and cosine of any arc whatever is less than 10; but the logarithmic tangents, cotangents, secants, and cosecants, admit of all possible values from 0 to infinity, whatever be the numerical value of the radius.

ON THE SIGNS OF TRIGONOMETRICAL QUANTITIES.

When geometrical quantities are expressed analytically, they are considered as measured from some given point or line, and as + or −, according as they lie on one or the other side of that point or line.

Thus, in the last figure but one, the signs are estimated from the diameter A E, and in the semicircle A I E they are considered as +; but as in the other semicircle E K A they fall on the other side of the diameter A E, they are then considered as −.

The cosines, being estimated from the centre C, are considered as + in the first quadrant A I; but as in the second quadrant I E, and the third E K, they fall on the other side of the centre C, they are then considered as −; and again, in the fourth quadrant K A, they become +, as in the first quadrant.

As $\tan = \frac{\text{rad.sin}}{\cos}$, the tangent is + in the first quadrant, because *sin* and *cos* are then both positive. But in the second quadrant cos is −, and sin +; therefore tan is −. In the third quadrant *sin* and *cos* are both −; therefore tan is +; and in the fourth quadrant we have again tan −.

The mutations of the signs of the cotangents, secants, and cosecants, may be traced in the same manner.

As the versed sines are estimated from A, the extremity of the diameter, and all in one direction, they are *positive* in every quadrant of the circle.

The following table exhibits the variations of the signs in each quadrant of the circle.

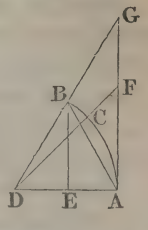
	Sin.	*Cos.*	*Tan.*	*Cot.*	*Sec.*	*Cosec.*	*Vers.*
1st quadrant	+	+	+	+	+	+	+
2d . . .	+	−	−	−	−	+	+
3d . . .	−	−	+	+	−	−	+
4th . . .	−	+	−	−	+	−	+

Proposition I.

The chord of 60° *and the tangent of* 45° *are each equal to the radius; the sine of* 30°, *the versed sine of* 60°, *and the cosine of* 60° *are each equal to half the radius; and the secant of* 60° *is equal to the diameter, or to double the radius.*

Let D be the centre of a circle, A B an arc of 60°, and A C an arc of 45°. Draw the chord B A; bisect the angle A B D with the line B E, and draw the tangent A G, meeting the secants D B G and D C F in G and F.

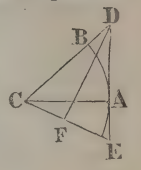
Now (Theo. 62. Geo.) A B the chord of 60° is equal to the radius; hence (Cor. 1. Theo. 3. Geo.) B E bisects A D and is at right angles to it. Therefore E A the versed sine of 60°, and D E the cosine of 60°, or the sine of 30°, are each equal to half the radius. And as B D is double of D E, by similar triangles D G the secant of 60° is double of D A the radius. Lastly, as the angle D A F is a right angle, and the angle A D F is 45°, or half a right angle, the angle A F D is also half a right angle. Hence the angles A D F and A F D being equal, A F the tangent of 45° is equal to A D the radius.



Proposition II.

The secant of any arc is equal to the sum of its tangent, and the tangent of half its complement.

Let A B be any arc, A D its tangent, and C D its secant; produce A D till D E is equal to D C, and join C E. Then the angle E is the complement of A C E; and as D C and D E are equal, a perpendicular from D on C E would bisect the angle D, therefore the angle E is also the complement of half the angle D. Hence A C E is equal to half A D C, or to half the complement of A C D, and consequently A E is the tangent of half the complement of A C D: therefore D A the tangent of A B, and A E the tangent of half its complement, are together equal to D C, the secant of the same arc.

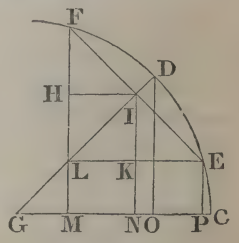


Remark. By this proposition, when the natural tangents have been computed, the natural secants are obtained by addition.

Proposition III.

If A *be the greater, and* B *the less of two arcs, it is proposed to investigate the relation between their* sines *and* cosines, *and the sine and cosine of their* sum, *and of their* difference.

Let G be the centre of the circle, D C the greater arc, A, and D E or D F the less one, B, join F E and G D; then G D bisects F E in I, and cuts it also at right angles. Draw F M, I N, D O, and E P perpendicular to G C, and I H, E L perpendicular to F M.



Then D O = sin A, O G = cos A; F I or I E = sin B; G I = cos B; F M = sin $\overline{A+B}$; G M = cos $\overline{A+B}$; E P = sin $\overline{A-B}$; and G P = cos $\overline{A-B}$. Also as the angles H F I and K I E, as well as the angles F I H and I E K are respectively equal;

and F I is equal to I E, the triangles F I H and I E K are identical, having F H equal to I K, and H I equal to K E. Hence F M = I N + F H and E P = I N − F H; G M = G N − I H and G P = G N + I H. Again, as the angles H I N and F I G are right angles, by taking the common angle H I G from each, we have the angles F I H and G I N equal; and as the angles H and N are right angles, the triangle F I H is similar to the triangle G I N, and therefore similar also to the triangle G D O.

We have therefore

$$G D : D O :: G I : I N, \text{ or } I N = \frac{D O \cdot G I}{G D} = \frac{\sin A \cdot \cos B}{\text{rad}}$$

$$G D : G O :: F I : F H, \text{ or } F H = \frac{G O \cdot F I}{G D} = \frac{\cos A \cdot \sin B}{\text{rad}}$$

$$G D : G O :: G I : G N, \text{ or } G N = \frac{G O \cdot G I}{G D} = \frac{\cos A \cdot \cos B}{\text{rad}}$$

$$G D : D O :: F I : I H, \text{ or } I H = \frac{D O \cdot F I}{G D} = \frac{\sin A \cdot \sin B}{\text{rad}}$$

Hence

$$F M, \text{ or } \sin \overline{A + B} = I N + F H = \frac{\sin A \cdot \cos B + \cos A \cdot \sin B}{\text{rad}}$$

$$E P, \text{ or } \sin \overline{A - B} = I N - F H = \frac{\sin A \cdot \cos B - \cos A \cdot \sin B}{\text{rad}}$$

$$G M, \text{ or } \cos \overline{A + B} = G N - H I = \frac{\cos A \cdot \cos B - \sin A \cdot \sin B}{\text{rad}}$$

$$G P, \text{ or } \cos \overline{A - B} = G N + H I = \frac{\cos A \cdot \cos B + \sin A \cdot \sin B}{\text{rad}}$$

And if radius be considered as unity, these formulæ become

$$\sin \overline{A + B} = \sin A \cdot \cos B + \cos A \cdot \sin B$$
$$\sin \overline{A - B} = \sin A \cdot \cos B - \cos A \cdot \sin B$$
$$\cos \overline{A + B} = \cos A \cdot \cos B - \sin A \cdot \sin B$$
$$\cos \overline{A - B} = \cos A \cdot \cos B + \sin A \cdot \sin B. \qquad (1)$$

Scholium.

Many curious and important formulæ may easily be deduced from the above expressions: the following are a few of the most useful. By adding and subtracting the first and second expressions, and the third and fourth severally, we get the following:—

$$\sin \overline{A + B} + \sin \overline{A - B} = 2 \sin A \cdot \cos B$$
$$\sin \overline{A + B} - \sin \overline{A - B} = 2 \cos A \cdot \sin B$$
$$\cos \overline{A + B} + \cos \overline{A - B} = 2 \cos A \cdot \cos B$$
$$\cos \overline{A - B} - \cos \overline{A + B} = 2 \sin A \cdot \sin B. \qquad (2)$$

Now (page 7) A is half the sum, and B half the difference of A + B

and $A-B$; hence, if for $\overline{A+B}$ in Formulæ 2, we put A, and for $\overline{A-B}$ we put B, instead of A in the same formulæ we must put $\frac{A+B}{2}$, and for B we must put $\frac{A-B}{2}$, and the formulæ will then stand in the following form:—

$$\sin A + \sin B = 2 \sin \frac{A+B}{2} \cdot \cos \frac{A-B}{2}$$

$$\sin A - \sin B = 2 \cos \frac{A+B}{2} \cdot \sin \frac{A-B}{2}$$

$$\cos A + \cos B = 2 \cos \frac{A+B}{2} \cdot \cos \frac{A-B}{2}$$

$$\cos B - \cos A = 2 \sin \frac{A+B}{2} \cdot \sin \frac{A-B}{2} \qquad (3)$$

If, in Formulæ 3, the arc B vanish, its sine will be *nothing*, and its cosine *radius;* and if the radius be considered as unity, the expressions give the following formulæ:—

$$\text{The 1st and 2d give, } \sin A = 2 \sin \frac{A}{2} \cdot \cos \frac{A}{2}$$

$$\text{The 3d gives, } 1 + \cos A = 2 \cos^2 \frac{A}{2}$$

$$\text{The 4th, } \qquad 1 - \cos A = 2 \sin^2 \frac{A}{2} \qquad (4)$$

From Formulæ 4, we infer that

$$2 \sin \frac{A+B}{2} \cdot \cos \frac{A+B}{2} = \sin \overline{A+B}.$$

$$2 \sin \frac{A-B}{2} \cdot \cos \frac{A-B}{2} = \sin \overline{A-B}.$$

$$\cos \frac{A}{2} = \sqrt{\frac{1+\cos A}{2}}.$$

$$\sin \frac{A}{2} = \sqrt{\frac{1-\cos A}{2}}. \qquad (5)$$

From Formulæ 3, we have $\overline{\sin A + \sin B} \cdot \overline{\sin A - \sin B} = 2 \sin \frac{A+B}{2} \cdot \cos \frac{A-B}{2} \cdot 2 \cos \frac{A+B}{2} \cdot \sin \frac{A-B}{2} = 2 \sin \frac{A+B}{2} \cdot \cos \frac{A+B}{2} \cdot 2 \sin \frac{A-B}{2} \cdot \cos \frac{A-B}{2} =$ (see Form. 5.) $\sin \overline{A+B} \cdot \sin \overline{A-B}$; whence $\sin \overline{A-B} : \overline{\sin A - \sin B} :: \overline{\sin A + \sin B} : \sin \overline{A+B}$. (6)

By transposing the first two equations of Form. 2, we have

$$\sin \overline{A+B} = 2 \sin A \cdot \cos B - \sin \overline{A-B}$$

$$\sin \overline{A+B} = 2 \cos A \cdot \sin B + \sin \overline{A-B} \qquad (7)$$

In the first of these expressions if $A = 30°$. $2 \sin A =$ radius; and in the second if $A = 60°$, $2 \cos A =$ radius; and hence if radius be unity, we have

$$\sin \overline{30° + B} = \cos B - \sin \overline{30° - B}$$
$$\sin \overline{60° + B} = \sin B + \sin \overline{60° - B}. \qquad (8)$$

By the former of these theorems, when the sines and cosines of all arcs below 30° have been computed, the sines may easily be continued to 60°; and then by the latter theorem, the sines of all arcs between 60° and the quadrant will readily be obtained.

If the first of Formulæ 3 be divided by the second, we have,

$$\frac{\sin A + \sin B}{\sin A - \sin B} = \frac{2 \sin \frac{A+B}{2} . \cos \frac{A-B}{2}}{2 \cos \frac{A+B}{2} . \sin \frac{A-B}{2}} = \frac{\tan \frac{A+B}{2}}{\tan \frac{A-B}{2}}$$

For (4, Trig., p. 67) $\tan = \frac{\sin}{\cos}$, and $\cot = \frac{1}{\tan} = \frac{\cos}{\sin}$.

Dividing the third of Form. 3 by the 4th, we have, by a similar reduction,

$$\frac{\cos A + \cos B}{\cos B - \cos A} = \frac{\cot \frac{A+B}{2}}{\tan \frac{A-B}{2}};$$

and, as equal fractions have their numerators and denominators in the same proportion, we have from these two equations the following proportions:—

$$\sin A + \sin B : \sin A - \sin B :: \tan \frac{A+B}{2} : \tan \frac{A-B}{2}$$
$$\cos A + \cos B : \cos B - \cos A :: \cot \frac{A+B}{2} : \tan \frac{A-B}{2}. \qquad (9)$$

By operating in the same way with the different expressions in Formulæ 3, we collect the following set of formulæ.

$$\frac{\sin A + \sin B}{\sin A - \sin B} = \frac{\tan \frac{A+B}{2}}{\tan \frac{A-B}{2}}$$

$$\frac{\cos A + \cos B}{\cos B - \cos A} = \frac{\cot \frac{A+B}{2}}{\tan \frac{A-B}{2}}$$

$$\frac{\sin A + \sin B}{\cos A + \cos B} = \frac{\tan \frac{A+B}{2}}{\text{rad}} = \tan \frac{A+B}{2} \text{ to rad unity}$$

$$\frac{\sin A + \sin B}{\cos B - \cos A} = \frac{\cot \frac{A-B}{2}}{\text{rad}} = \cot \frac{A-B}{2} \text{ to rad unity}$$

$$\frac{\sin A - \sin B}{\cos A + \cos B} = \frac{\tan \frac{A-B}{2}}{\text{rad}} = \tan \frac{A-B}{2} \quad ,,$$

$$\frac{\sin A - \sin B}{\cos B - \cos A} = \frac{\cot \frac{A+B}{2}}{\text{rad}} = \cot \frac{A+B}{2} \quad ,, \qquad (10)$$

It will furnish an easy and agreeable exercise to the student, to go over the different steps of the operations, by which these expressions are deduced.

If, in the second, third, and sixth of Formulæ 10, the arc B be taken $= 0$, we have,

$$\frac{1 + \cos A}{1 - \cos A} = \frac{\cot \frac{A}{2}}{\tan \frac{A}{2}} = \cot^2 \frac{A}{2} = \frac{1}{\tan^2 \frac{A}{2}}$$

$$\frac{\sin A}{1 + \cos A} = \tan \frac{A}{2} = \frac{1}{\cot \frac{A}{2}}; \quad \frac{\sin A}{1 - \cos A} = \cot \frac{A}{2} = \frac{1}{\tan \frac{A}{2}} \qquad (11)$$

The foregoing formulæ might all have been investigated *geometrically*, though they could not have been deduced with equal conciseness. We shall afterwards take occasion to shew how a few of them may be directly deduced from geometrical principles, but we shall leave the greater part of them to be so proved by the ingenious student whose taste or curiosity the exercise may gratify.

ON THE CONSTRUCTION OF TABLES OF NATURAL SINES, TANGENTS, &c.

We have seen above, that $\cos \frac{A}{2} = \sqrt{\frac{1 + \cos A}{2}}$; hence if A be an arc whose cos is known, the cos of $\frac{A}{2}$, its half, may be computed. Now 60° is an arc of that description, its cosine (Proposition 1. Trig.) being $\frac{1}{2}$ to radius unity. Hence $\cos 30° = \sqrt{\frac{1 + \cos 60°}{2}} = \sqrt{\frac{1 + \frac{1}{2}}{2}} = \frac{\sqrt{3}}{2}$. In this way the cosine of 15°, 7° 30′, &. may be computed; till, after twelve succes-

sive bisections, the cosine of $52''\ 44'''\ 3^{iv}\ 45^{v}$ will be obtained. Then knowing the cos, we readily get the sine; for $\sin^2 = \text{rad}^2 - \cos^2$, $= \overline{\text{rad} + \cos} \cdot \overline{\text{rad} - \cos}$; or $\sin = \sqrt{\overline{1 + \cos} \cdot \overline{1 - \cos}}$, to radius unity. Thus therefore the sine of $52''\ 44'''\ 3^{iv}\ 45^{v}$ may be found.

Now as the sines of very small arcs vary nearly as the arcs themselves do, we have by analogy, as $52''\ 44'''\ 3^{iv}\ 45^{v}$ is to the sine of $52''\ 44'''\ 3^{iv}\ 45^{v}$, so is $1'$ of arc to the sine of $1'$, and hence the sine of $1'$ may be computed.

Thus having the sine and cosine of $1'$, we obtain the sine of $2'$ from Formula 4,

$$\sin 2\ A = 2 \sin A \cdot \cos A,$$
$$\text{or } \sin 2' = 2 \sin 1' \cdot \cos 1'.$$

For the sine of $3'$, and every succeeding minute, we have from Formula 7,

$$\sin \overline{A + B} = 2 \sin A \cdot \cos B - \sin \overline{A - B}.$$

Which expression, if A be taken $= 2', 3', 4'$, &c. and $B = 1'$, becomes

$$\sin 3' = 2 \sin 2' \cdot \cos 1' - \sin 1'$$
$$\sin 4' = 2 \sin 3' \cdot \cos 1' - \sin 2'$$
$$\sin 5' = 2 \sin 4' \cdot \cos 1' - \sin 3', \text{ &c.}$$

Having computed the sines of a few minutes in this manner, the correctness of the computation may be ascertained by the application of Formula 6, viz.

$$\sin \overline{A - B} : \sin A - \sin B :: \sin A + \sin B :: \sin \overline{A + B}.$$

Here let $A = 3'$ and $B = 2'$, and the expression is

$$\sin 1' : \sin 3' - \sin 2' :: \sin 3' + \sin 2' : \sin 5'.$$

If the sine of $5'$, computed in this way, agree with the sine of the same arc computed by the former, or any other independent method, the result may be considered as correct.

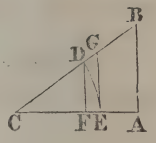
By the method here described the sines of all arcs may be computed, and their cosines may then be obtained by the formula, $\cos = \sqrt{\overline{1 + \sin} \cdot \overline{1 - \sin}}$, their tangents by $\tan = \frac{\sin}{\cos}$, their cotangents by $\cot = \frac{\cos}{\sin}$, their secants by $\sec = \frac{1}{\cos}$, &c.

Or the secants may be deduced from the tangents by Prop. II. Trigonometry.

Proposition IV.

In any right-angled plane triangle, as the hypothenuse is to either of the sides, so is the radius to the sine of the angle opposite to that side: and as either of the sides is to the other side, so is the radius to the tangent of the angle opposite to that other side.

Let A B C be a plane triangle right angled at A; and from C as a centre with any radius C D, let the arc D E be described, meeting C B and C A in the points D and E; and from D and E, let D F and E G be drawn perpendicular to A C, then D F is the sine, and E G the tangent of the arc E D, or of the angle C.



The triangles C F D, C E G, and C A B are similar, as they have the common angle C, and each of the angles C F E, C E G, and C A B is a right angle. Hence C B : B A :: C D : D F; or C B : B A :: rad : sin C. And C A : A B :: C E : E G, or C A : A B :: rad : tan C.

Cor. 1. C B . sin C = rad . B A, and C A . tan C = rad . A B, or if *rad* be considered as unity, B A = C B . sin C, and B A = C A . tan C.

Cor. 2. C B : C A :: C D : C F; or C B : C A :: rad : cos C. Therefore C B . cos C = rad . C A; or C A = C B . cos C, radius being unity.

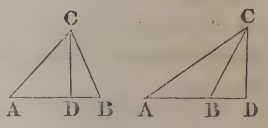
Cor. 3. C A : C B :: C E : C G; or C A : C B :: rad : sec C. Hence C A . sec C = rad . C B; or C B = C A . sec C, radius being unity.

Cor. 4. To the hypothenuse as a radius, each of the other sides is the sine of its opposite angle; and to one of the sides as a radius, the other is the tangent of its opposite angle, and the hypothenuse is the secant of the same angle.

Proposition V.

The sides of plane triangles are to each other as the sines of the opposite angles.

From C, any angle of the triangle A B C, draw C D, a perpendicular on the opposite side, or that side produced.



Then as the triangle A C D is right angled at D, we have A C . sin A = R . C D; and for the same reason B C . sin B = R . C D (Prop. 4.). Hence A C . sin A = B C . sin B, and consequently A C : sin B :: B C : sin A . or A C : B C :: sin B : sin A.

Note.—R is put here for *radius.*

Proposition VI.

In every plane triangle if a perpendicular be drawn from any of the angles on the opposite side, the segments of that side are to one another as the tangents of the parts into which the opposite angle is divided by the perpendicular.

For (*see the last fig.*) C D . tan A C D = A D . R, and C D . tan D C B = D B . R (Prop. 4.). Hence A D . R : D B . R :: C D . tan A C D : C D . tan B C D. Or A D : D B :: tan A C D : tan D C B.

Cor. A D : D B :: cot A : cot B; for tan A C D = cot A and tan D C B = cot B.

Proposition VII.

The sum of any two sides of a triangle is to their difference, as the tangent of half the sum of the angles opposite to those sides is to the tangent of half their difference.

Let A B C be any plane triangle. Then A B : A C :: sin C : sin B (Prop. 5.); whence A B + A C : A B − A C : sin C + sin B; sin C − sin B (Geom. Prop. 69). But (Prop. 3. Trig. Formula 9.)

$$\sin C + \sin B : \sin C - \sin B :: \tan \frac{C+B}{2} : \tan \frac{C-B}{2}.$$

Therefore A B + A C : A B − A C :: $\tan \frac{C+B}{2} : \tan \frac{C-B}{2}$.

Proposition VIII.

If a perpendicular be drawn from any angle of a plane triangle to the opposite side, or base, the sum of the segments of the base is to the sum of the other two sides, as the difference of those sides is to the difference of the segments of the base.

For (Geo. Theo. 47. Cor.) the rectangle under the sum and difference of the segments of the base is equal to the rectangle under the sum and difference of the sides; therefore (Geo. Theo. 73.) the sum of the segments of the base is to the sum of the other two sides, as the difference of those sides is to the difference of the segments of the base.

Proposition IX.

To find the cosine of any angle of a plane triangle when all its sides are given.

Let A B C (Trig. Prop. 5.) be any plane triangle, and C D a perpendicular upon A B, or upon A B produced. Then when the per-

pendicular falls within the triangle, we have (Geo. Prop. 46.) $AC^2 = AB^2 + BC^2 - 2AB \cdot BD$. But (Trig. Prop. 4. Cor. 2.) $BD = BC \cdot \cos B$, to radius unity. Hence $AC^2 = AB^2 + BC^2 - 2AB \cdot BC \cdot \cos B$; or $2AB \cdot BC \cdot \cos B = AB^2 + BC^2 - AC^2$, whence $\cos B = \frac{AB^2 + BC^2 - AC^2}{2AB \cdot BC}$.

If CD fall without the triangle, we have (Geo. Prop. 45.) $AC^2 = AB^2 + BC^2 + 2AB \cdot BD$. But $BD = BC \cdot \cos CBD = -BC \cdot \cos ABC$, whence $AC^2 = AB^2 + BC^2 - 2AB \cdot BC \cdot \cos ABC$, and therefore as before, $\cos ABC = \frac{AB^2 + BC^2 - AC^2}{2AB \cdot BC}$, radius being unity; and $\cos ABC = \text{rad.} \frac{AB^2 + BC^2 - AC^2}{2AB \cdot BC}$, to any given radius.

Cor. If the angles of a plane triangle be represented by the capital letters A, B, and C, and the sides opposite those angles respectively by the small letters a, b, and c, the above expressions, when radius is unity, give us

$$\cos A = \frac{b^2 + c^2 - a^2}{2bc} \quad \cos B = \frac{a^2 + c^2 - b^2}{2ac} \quad \cos C = \frac{a^2 + b^2 - c^2}{2ab}.$$

Proposition X.

It is proposed to investigate the relation between the sides of a plane triangle, and the sine and cosine of the half of any of its angles.

Adopting the notation in the corollary to the preceding proposition, we have,

$\cos A = \frac{b^2 + c^2 - a^2}{2bc}$. But (Form. 4. Schol. Prop. 3. Trig.) $1 + \cos A = 2\cos^2 \frac{A}{2}$, therefore $2\cos^2 \frac{A}{2} = 1 + \frac{b^2 + c^2 - a^2}{2bc} = \frac{2bc}{2bc} + \frac{b^2 + c^2 - a^2}{2bc} = \frac{2bc + b^2 + c^2 - a^2}{2bc}$. But (Geo. Theo. 41.) $2bc + b^2 + c^2 = \overline{b + c}^2$, therefore $2\cos^2 \frac{A}{2} = \frac{\overline{b + c}^2 - a^2}{2bc}$; or $\cos^2 \frac{A}{2} = \frac{\overline{b + c}^2 - a^2}{4bc}$. Now, (Geo. Theo. 43.) $\overline{b + c}^2 - a^2 = \overline{b + c + a} \cdot \overline{b + c - a}$. Hence $\cos^2 \frac{A}{2} = \frac{\overline{b + c + a} \cdot \overline{b + c - a}}{4bc} = \frac{\frac{b + c + a}{2} \cdot \frac{b + c - a}{2}}{bc} = \frac{\frac{b + c + a}{2} \cdot \left(\frac{b + c + a}{2} - a\right)}{bc}$; for the subtraction of the half of any quantity is an operation equivalent to

adding the half of it, and then subtracting the whole of the quantity from the sum.

If $\frac{b+c+a}{2}$ be put = S the above expression is $\cos^2\frac{A}{2} = \frac{S \cdot \overline{S-a}}{b\,c}$ to radius unity, or $\cos^2\frac{A}{2} = \text{rad}^2\,\frac{S \cdot \overline{S-a}}{b\,c}$ to a given radius. Hence $\cos\frac{A}{2} = \sqrt{\text{rad}^2\,\frac{S \cdot \overline{S-a}}{b\,c}}$. Again, (Form. 4. Schol. Prop. 3. Trig.) $1 - \cos A = 2\sin^2\frac{A}{2}$; therefore $2\sin^2\frac{A}{2} = 1 - \frac{b^2+c^2-a^2}{2\,b\,c} = \frac{2\,b\,c}{2\,b\,c} - \frac{b^2+c^2-a^2}{2\,b\,c} = \frac{a^2-b^2-c^2+2\,b\,c}{2\,b\,c} = \frac{a^2-(b^2+c^2-2\,b\,c)}{2\,b\,c}$. But $b^2+c^2-2\,b\,c = \overline{b-c}^2$ (Geo. Theo. 42.); hence $2\sin^2\frac{A}{2} = \frac{a^2-\overline{b-c}^2}{2\,b\,c}$, or $\sin^2\frac{A}{2} = \frac{a^2-\overline{b-c}^2}{4\,b\,c} = \frac{\overline{a+b-c} \cdot \overline{a+c-b}}{4\,b\,c} = \frac{\frac{a+b-c}{2} \cdot \frac{a+c-b}{2}}{b\,c} = \frac{\frac{a+b+c}{2} - c \cdot \frac{a+b+c}{2} - b}{b\,c}$ Or putting S, as above, for $\frac{a+b+c}{2}$, we have $\sin^2\frac{A}{2} = \frac{\overline{S-b} \cdot \overline{S-c}}{b\,c}$, to radius unity; or $\sin^2\frac{A}{2} = \text{rad}^2 \cdot \frac{\overline{S-b} \cdot \overline{S-c}}{b\,c}$ to a given radius. Hence $\sin\frac{A}{2} = \sqrt{\text{rad}^2 \cdot \frac{\overline{S-b} \cdot \overline{S-c}}{b\,c}}$.

By similar processes we might deduce like expressions for the angles B and C. The resulting formulæ for A, which may represent *any angle*, are arranged as under.

$$\sin\frac{A}{2} = \sqrt{\text{rad}^2 \cdot \frac{\overline{S-b} \cdot \overline{S-c}}{b\,c}}; \quad \cos\frac{A}{2} = \sqrt{\text{rad}^2 \cdot \frac{S \cdot \overline{S-a}}{b\,c}};$$

In logarithms these formulæ are,

$$\log\cos\frac{A}{2} = \frac{20 + \log S + \log\overline{S-a} - \log b - \log c}{2}$$

$$\log\sin\frac{A}{2} = \frac{20 + \log\overline{S-b} + \log\overline{S-c} - \log b - \log c}{2}.$$

Proposition XI.

If A *and* B *be any two arcs, it is proposed to demonstrate geometrically the expressions forming Formulæ* 10, *Proposition* III.

Let C E be the arc A, and C D the arc B; draw the sines D L and E K, and produce E K to meet the circle again in I. Draw D M F parallel to the diameter G H C; draw the radii E H, D H, and I H; and join E F, F I, and I D. Now (Theo. 59. Geo.) E I is bisected in K, therefore M I, the sum of M K and K I, is the sum of the sines K E and L D; and M E is the difference of the same sines. The arc D C I, or the sum of the arcs C D and C E, is the measure of the angle at the centre D H I; therefore the half of D I, or half the sum of C D and C E, is the measure of the angle D F I, at the circumference: and in the same manner may half the difference of C D and C E be shown to be the measure of the angle D F E.

But as F M is perpendicular to E I, therefore M I : M E :: tan I F M : tan E F M; or as sin A + sin B : sin A − sin B :: tan $\frac{A+B}{2}$: tan $\frac{A-B}{2}$.

As H K is the cosine of E C, and H L is the cosine of D C, F M is the sum, and K L or M D the difference of the cosines of C D and C E. But F M : M D :: tan F I M : tan D I M, or :: cot M F I : tan E F D. That is, cos A + cos B : cos B − cos A :: cot $\frac{A+B}{2}$: tan $\frac{A-B}{2}$. Again, F M : M I :: rad : tan I F M; or cos A + cos B : sin A + sin B :: rad : tan $\frac{A+B}{2}$. But F M : M E :: rad : tan M F E; or cos A + cos B : sin A − sin B :: rad : tan $\frac{A-B}{2}$. And I M : M D :: rad : tan M I D cor sin A + sin B : cos B − cos A :: rad : tan $\frac{A-B}{2}$. In a similar manner may the other formulæ be investigated.

EXAMPLES FOR EXERCISE IN THE THEORY OF TRIGONOMETRY.

1. Show *geometrically* that $\text{rad} \cdot \overline{\text{rad} + \cos A} = 2 \cos^2 \frac{A}{2}$; that $\text{rad} \cdot \overline{\text{rad} - \cos A} = 2 \sin^2 \frac{A}{2}$; that $\text{rad} \cdot \sin 2A = 2 \sin A \cdot \cos A$; and that $\text{vers } A \cdot \text{suvers } A = \sin^2 A$.

2. Prove that $\tan A + \tan B = \frac{\sin \overline{A + B}}{\cos A \cdot \cos B}$, radius being unity.

3. Show that in any plane triangle the base is to the sum of the other two sides as the sine of half the vertical angle is to the cosine of half the difference of the angles at the base.

4. Show that the base of a plane triangle is to the difference of the other two sides as the cosine of half the vertical angle is to the sine of half the difference of the angles at the base.

5. The difference of two sides of a triangle is to the difference of the segments of the third side, made by a perpendicular from the opposite angle, as the sine of half the vertical angle is to the cosine of half the difference of the angles at the base; required the proof?

6. a, b, c, being the sides of a plane triangle, and A the angle opposite the side a, and S half the sum of a, b, and c; show that $\tan^2 \frac{A}{2} = \text{rad}^2 \frac{\overline{S - b} \cdot \overline{S - c}}{S \cdot \overline{S - a}}$.

7. Prove that $\tan \overline{45^\circ \pm A} = \frac{1 \pm \tan A}{1 \mp \tan A}$, radius being unity.

8. Demonstrate *geometrically* that $\text{rad} \cdot \sin 2A = \tan A \cdot \text{suvers } 2A$.

9. As the greater of two sides of a triangle is to the less, so radius is to the tangent of a certain angle. Show that radius is to the tangent of the difference between this angle and half a right angle, as the tangent of half the sum of the angles at the base is to the tangent of half their difference.

ELEMENTARY PRINCIPLES

OF

SPHERICAL TRIGONOMETRY.

1. A SPHERE is a solid bounded by a curve surface, every point of which is at the same distance from a point within, called the centre.

Cor. 1. A sphere may be conceived to be generated by the revolution of a semicircle about its diameter.

Cor. 2. The section of a sphere, by a plane passing through the centre, *is a circle;* for every straight line drawn in the plane, from the centre to the surface of the sphere, is equal to the radius.

Cor. 3. All circles of a sphere whose planes pass through the centre are equal; and any two of them bisect each other.

2. The circles of a sphere whose planes pass through the centre are called *great circles;* and those whose planes do not pass through the centre are called *less circles.*

3. The pole of a circle is a point on the surface of the sphere equally distant from every point in the circumference of the circle.

4. A spherical angle is an angle on the surface of a sphere contained by the arcs of two great circles at their point of intersection; and it is the same with the inclination of the planes of the circles, or with the plane angle formed by the tangents of the arcs at the point of intersection.

5. A spherical triangle is a figure formed upon the surface of a sphere by the intersection of three planes which meet in the centre of the sphere.

Proposition I.

Every section of a sphere by a plane is a circle.

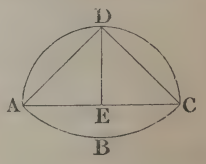
If the plane pass through the centre, then, as every point in the surface of the sphere is equidistant from its centre, the section is a plane figure, every point of whose periphery is equidistant from a certain point within it, and the figure is therefore a circle.

But if the plane do not pass through the centre, let C D E F be the section, and C, D any two points in its periphery. Let A B be a perpendicular from the centre A on the plane of the section, and join A C, A D. Then the angles A B C, A B D are right angles, A C is equal to A D, and the perpendicular A B common to both the right-angled triangles A B C, A B D; therefore the bases B C and B D are equal. Hence all lines drawn from B in the plane C D E F, to the periphery of that plane, are equal; and the figure is consequently a circle.

Proposition II.

The distance of a great circle from its pole is a quadrant.

Let D be the pole of the great circle A B C, and A D C a great circle passing through D; then A D C is a semicircle (Cor. 3. Defin. 1. Spherics); and as D is equidistant from every part of the circumference A B C (Defin. 3. Spherics), D A and D C are quadrants.

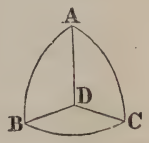


Cor. Every circle has two poles, one on each side of its plane, and they are at the extremities of a diameter perpendicular to that plane.

Proposition III.

If two great circles, as B A, C A, *intersect each other in* A, *on the surface of a sphere whose centre is* D, *and if* B C *be an arc of the great circle whose pole is* A, B C *is the measure of the spherical angle* B A C.

For join A D, B D, and C D, then as A is the pole of B C, A B and A C are quadrants, and therefore the angles A D B and A D C are right angles.



Hence the angle B D C is the inclination of the planes of A B and A C, and it is therefore equal to the spherical angle B A C. But B D C is measured by the arc B C, therefore the spherical angle B A C is also measured by the arc B C.

Cor. 1. As A D is perpendicular to D B and D C, it is perpendicular to the plane B D C, therefore the planes A D B and A D C which pass through A D are also perpendicular to the plane B D C; and consequently the spherical angles A B C and A C B are right angles. Hence the great circles which pass through the pole of another great circle, cut it at right angles.

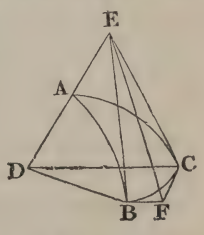
Cor. 2. Great circles, whose planes are at right angles to the plane of one and the same great circle, or which cut the same great circle at right angles, meet in the poles of that circle.

Cor. 3. If the planes of two great circles be at right angles to each other, each of the circles passes through the poles of the other; and if the circumference of one great circle pass through the poles of another, the planes of those circles are at right angles.

Proposition IV.

In isosceles spherical triangles, the angles which are opposite the equal sides are equal; and if two angles of a spherical triangle are equal, the sides which are opposite those angles are equal.

Let A B C be an isosceles spherical triangle, A B and A C being the equal sides, and let D be the centre of the sphere. Let B E and C E be tangents to A B and A C, and B F and C F two tangents drawn from B and C in the plane D B C, intersecting each other in F, and join F E. Then as A B and A C are equal, their tangents B E and C E are equal; and they have, therefore, the common secant D E; and (Geo. Theo. 66. Cor. 2) B F is equal to F C, and F E is common to the triangles B F E and C F E the plane angle E B F is equal to the plane angle E C F, or the spherical angles A B C and A C B are equal.



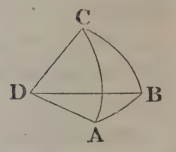
Again, the same construction being made, suppose the spherical

angles A B C and A C B, or the plane angles E B F and E C F, to be equal; then as D B is at right angles to B E and B F, it is at right angles to the plane B E F; and therefore the plane B D C, which passes through D B, is at right angles to the plane B E F. For a like reason, the plane B D C is at right angles to the plane E C F, and therefore F E, the common section of the planes E B F and E F C, is at right angles to the plane D B C. (Geo. Prop. 94.) Hence E F B and E F C are right angles, and consequently as the angles E B F and E C F are equal, and the side B F equal to the side F C, the triangles B E F and C E F are identical; whence B E is equal to C E, and as D B and D C are also equal, and the angles D B E and D C E being right angles are equal, the angle E D B is equal to the angle E D C; therefore A B is equal to A C.

Proposition V.

Any two sides of a spherical triangle are together greater than the third side.

Let A B C be a spherical triangle, and let D be the centre of the sphere: join A D, B D, and C D. Then the solid angle at D is contained by three plane angles, A D B, A D C, and B D C, any two of which are together greater than the third. (Geo. Theo. 95.)



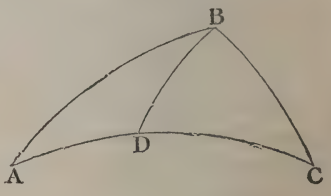
But these angles are measured respectively by the arcs A B, A C, and B C, therefore any two sides of the spherical triangle A B C are together greater than the third side.

Remark. The three sides of a spherical triangle are together less than the circumference of a great circle. For the plane angles at the point D are together less than four right angles, and consequently the sides of the triangle, which measure the plane angles at D, must together be less than the circumference of a great circle.

Proposition VI.

In a spherical triangle the greater side is opposite the greater angle, and the greater angle opposite the greater side.

Let A B C be a spherical triangle; if the angle B be greater than the angle A, the side A C is greater than the side B C.



For let A B D, a part of A B C, be equal to A, then A D is equal to B D. (Spher. Prop. 4.) But (Spher. Prop. 5.) the sum of B D and D C is greater than B C; therefore A C, which is equal to the sum of B D and D C, is greater than B C.

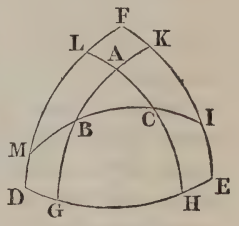
Again, if A C be greater than B C, the angle A B C is greater than the angle A.

For if A B C is not greater than A, it must either be equal to it, or less. If it were equal, then A C would be equal to B C (Spher. Prop. 4.), which it is not. And if A B C were less than A, A C would be less than B C, by the former part of this proposition, which it is not. Hence as A B C is neither equal to nor less than A, it must be greater.

Proposition VII.

Three great circles, whose poles are the angular points of a spherical triangle, will, by their intersection, form another triangle whose angular points are the poles of the great circles, which, by their intersection, form the sides of the first triangle; and the sides of each of the triangles are the supplements of the arcs which measure the angles of the other.

In the annexed figure, if A, B, and C be the poles of D E, E F, and F D respectively, then D, E, and F are the poles of A C, A B, and B C respectively; and D E, E F, and F D are respectively the supplements of the arcs which measure the angles B A C, A B C, and A C B; and A C, A B, and B C will respectively be the supplements of the arcs which measure the angles D, E, and F.



For let A B, A C, and B C be produced both ways, till they meet D E, E F, and D F in G, H, I, K, L, and M. Then G H is the measure of the angle B A C, K I the measure of the angle A B C, and M L the measure of the angle A C B. (Spher. Prop. 3.) And as A is the pole of D E, the angle A H D is a right angle (Spher. Prop. 3. Cor. 1.), and for a like reason, the angle C L D is a right angle; hence (Prop. 3. Cor. 2. Spherics) D is the pole of L H. In the same way it may be shown that E is the pole of G K, and F the pole of M I; and consequently L H is the measure of the angle D, G K the measure of the angle E, and M I the measure of the angle F.

Now as D is the pole of L H, D H is a quadrant; and as E is the pole of G K, E G is a quadrant; therefore E G and D H, or E D and G H together, are equal to a semicircle. Hence D E is the supplement of G H, the measure of the angle B A C. And in like manner it may be shown that E F is the supplement of K I, the measure of A B C; and D F the supplement of M L, the measure of A C B.

Again, because A is the pole of D E, A G is a quadrant; and because B is the pole of E F, B K is a quadrant. Hence A G and B K, or K G and A B together, are equal to a semicircle; or A B is the supplement of G K, the measure of the angle E. And in the same way it may be shown that A C is the supplement of L H, the measure of D; and B C the supplement of M I, the measure of F.

Proposition VIII.

The sum of the interior angles of a spherical triangle is greater than two, and less than six right angles.

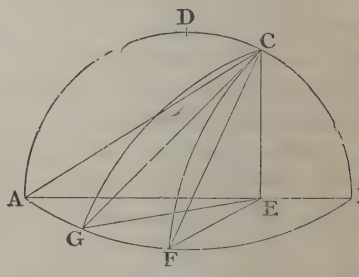
For (see last figure) the measures of the angles A, B, C, in the triangle A B C, together with the three sides of the supplemental triangle D E F, are equal to three semicircles. But the three sides of the triangle D E F are less than two semicircles (Spher. Prop. 5. Remark), therefore the measures of the angles A, B, and C are greater than a semicircle; hence the angles A, B, and C are greater than two right angles.

And as the interior angles of any triangle, together with the exterior, are equal to six right angles, the interior angles alone must be less than six right angles.

Proposition IX.

If to the circumference of a great circle, from a point in the surface of a sphere, which is not the pole of that circle, arcs of great circles be drawn, the greatest of those arcs is that which passes through the pole of the first-mentioned circle, and of the other arcs that which is nearer to the greatest is greater than the more remote.

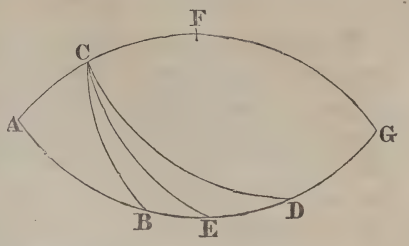
Let D be the pole of A G F B, C G and C F arcs of any other great circles, drawn from C to A G F B. The planes A D B and A F B are perpendicular to each other (Prop. 3. Cor. 3. Spherics), and A B is a diameter. From C in the plane A D B draw C E perpendicular to A B, join G E and F E; and C E is perpendicular to A E, G E, and F E (Defin. 1. and 2. Planes); and (Prop. 51. Geom.) A E is greater than E G, and E G than F E. Therefore, in the right-angled plane triangles A E C, G E C, and F E C, having the common perpendicular E C, the hypothenuse A C is greater than G C, and G C greater than C F. Hence the arc A D C is greater than the arc G C; and G C is greater than C F, which is more remote from A D C.



Proposition X.

In right-angled spherical triangles the sides containing the right angle are of the same affection as their opposite angles; that is, if the sides be greater or less than quadrants, the opposite angles are greater or less than right angles; and, conversely, if the angles be greater or less than right angles, the opposite sides are greater or less than quadrants.

Let A B C be a spherical triangle, right angled at A; produce A C, A B, till they meet in G, and bisect A B G and A C G in E and F. Then F is the pole of A B G, and E the pole of A F G. Join C E, then C E is a quadrant, and the angle E C A a right angle. Hence, when A B is less than A E, or less than a quadrant, the opposite angle B C A is less than the angle E C A, or less than a right angle.



Again, let A D C be a spherical triangle, right angled at A, having A D greater than a quadrant, then the angle D C A is greater than the angle E C A, or greater than a right angle.

In a similar manner may the converse be demonstrated.

Proposition XI.

If the sides which contain the right angle of a right-angled spherical triangle be of the same affection, the side opposite the right angle is less than a quadrant; but if they be of different affections, the side opposite the right angle is greater than a quadrant.

For (see the last figure) when A C and A B are each less than a quadrant, C B being farther from C F G than C E, is therefore less than C E, or less than a quadrant. (Prop. 9. Spherics.) But if A D be greater, and A C be less than a quadrant, then C D being nearer C F G than C E, is greater than C E, or greater than a quadrant.

Again, in the right-angled triangle C G B, where C G and G B are each greater than a quadrant, C B being farther from C F G than C E, is less than C E, or less than a quadrant.

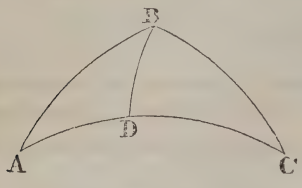
Cor. 1. Hence, conversely, if the hypothenuse of a right-angled spherical triangle be greater than a quadrant, the sides are of different affections; and if the hypothenuse be less than a quadrant, the sides are of the same affection.

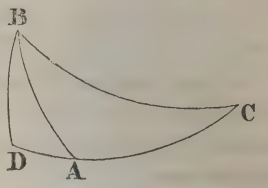
Cor. 2. As the oblique angles of a right-angled spherical triangle have the same affection with the opposite sides, those angles are of the same or different affections, according as the hypothenuse is less or greater than a quadrant.

Cor. 3. When a side and the adjacent angle are of the same affection, the hypothenuse is less than a quadrant; and when a side and the adjacent angle are of different affections, the hypothenuse is greater than a quadrant.

Proposition XII.

In any spherical triangle, if the perpendicular from one of the angles upon the opposite side fall within the triangle, the other angles of the triangle are of the same affection; but if the perpendicular fall without the triangle, the other angles are of different affections.





Let A B C be a triangle, and B D a perpendicular drawn from B on A C, or A C produced.

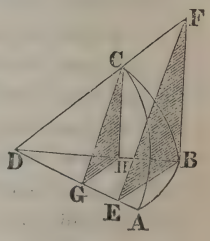
When B D falls within the triangle, the angles A and C of the right-angled triangles A D B and B D C being of the same affection with B D, are of the same affection with each other.

But when the perpendicular falls without the triangle, the angles D A B and D C B, being of the same affection with B D, are of the same affection with each other; hence B A C (the supplement of D A B) and C are of different affections.

Proposition XIII.

In any right-angled spherical triangle, the rectangle of radius and the sine of either of the sides containing the right angle is equal to the rectangle of the tangent of the other side, and the cotangent of the angle opposite to that side.

Let A B C be a spherical triangle, right angled at B; and let D be the centre of the sphere. From B, in the plane D A B, let B E be drawn perpendicular to D A; and from E in the plane A C D, let E F be drawn also perpendicular to D A, meeting D C produced in F, and join F B. Then as D E is perpendicular to E F and E B at their point of meeting, it is perpendicular to the plane E B F (Geom. Prop. 87), therefore the plane E B F is perpendicular to the plane A D B, which passes through D E. (Geom. Prop. 93.) And as the angle C B A is a right angle, the plane F D B is at right angles to the plane A D B; hence B F, the common section of the planes E B F and F D B, is at right angles to the plane D A B (Geom. Prop. 94); and consequently the angles F B D and F B E are right angles, and F B is therefore the tangent of B C. Now, in the right-angled plane triangle E B F, we have E B : B F : : rad : tan



B E F. But E B is sine of A B, and the angle B E F is the angle made by the planes A D C and A D B, or it is equal to the spherical angle B A C. Hence sin A B : tan B C : : rad : tan B A C. But rad : tan B A C : : cot B A C : rad (Art. 5, page 67); therefore sin A B : tan B C : : cot B A C : rad.

Or rad . sin A B = tan B C . cot B A C.

And similarly we have rad . sin B C = tan A B : cot B C A.

Proposition XIV.

In any right-angled spherical triangle, the rectangle of radius and the sine of either of the sides containing the right angle is equal to the rectangle of the sine of the angle opposite that side and the sine of the hypothenuse.

From C (see the last figure) in the plane C D A, let C G be drawn perpendicular to A D; and from G in the plane B D A let G H be drawn also perpendicular to D A, meeting D B in H, and join C H.

Then it may be shown exactly, as in the last proposition, that C H G is a right-angled plane triangle, and that C H is the sine of B C; and the angle C G H is equal to the spherical angle B A C.

Now in the plane triangle C G H, we have C G : C H : : rad : sine C G H, or

sin A C : sin B C : : rad : sin B A C.

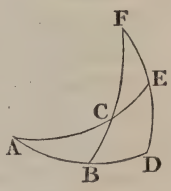
Hence rad . sin B C = sin A C . sin B A C.

And similarly we have rad . sin A B = sin A C . sin B C A.

Proposition XV.

In any right-angled spherical triangle A B C (B *being the right angle*) *the following equations obtain.*

Viz. 1. rad . sin A B = tan B C . cot A
2. rad . sin A B = sin A C . sin C
3. rad . sin B C = tan A B . cot C
4. rad . sin B C = sin A C . sin A
5. rad . cos A C = cot A . cot C
6. rad . cos A C = cos A B . cos B C
7. rad . cos A = tan A B . cot A C
8. rad . cos A = cos B C . sin C
9. rad . cos C = tan B C . cot A C
10. rad . cos C = cos A B . sin A



The first four of these equations are demonstrated in the two preceding propositions. To show the truth of the other equations, let D F be the great circle of which A is the pole, and produce B C till it meets D F in F; produce A C and A B also till they meet D F in E and D. Then as the angles B and D are right angles, F is the pole of A B; B D, the measure of the angle F, is the complement of

A B; E D, the measure of the angle A, is the complement of E F; E C is the complement of A C; C F is the complement of B C; the angle E C F is equal to the vertical angle A C B; and the angle C E F is a right angle.

Now by Propositions 13 and 14, in the right-angled triangle C E F, we have

rad . sin C E = tan E F . cot E C F; or rad . cos A C = cot A, cot A C B. (Equation 5.)

rad . sin C E = sin C F . sin C F E; or rad . cos A C = cos B C . cos A B. (Equation 6.)

rad . sin E F = tan C E . cot F; or rad . cos A = cot A C . tan A B. (Equation 7.)

rad . sin E F = sin C F . sin F C E; or rad . cos A = cos B C . sin A C B. (Equation 8.)

And by taking C as the pole of a great circle, and producing B C A C, and completing the figure as above, the ninth and tenth may be deduced exactly in the same manner as the seventh and eighth have been.

Scholium.

Each of the above equations may be expressed in the form of an analogy; and if any three of the quantities which with radius form one of the equations be given, the fourth may be found by proportion.

But in recollecting the different equations, there may be sometimes a risk of confounding one of them with another; and an expedient which may aid in recollecting the equation which is appropriate to the solution of any case that may be proposed, must be considered as very desirable.

Baron Napier, a Scotch nobleman, the celebrated inventor of logarithms, had the fortune to observe that, by a particular classification of the parts of a right-angled triangle, all the equations might be included in two, easy of recollection, and simple in their application.

These equations of Napier (commonly called *Napier's Rules for the Circular Parts*) may be thus explained.

If in a right-angled spherical triangle, *the right angle be disregarded*, there remain for consideration only five other parts: viz. the sides which include the right angle, the hypothenuse, and the oblique angles. Now the sides which include the right angle, the *complement* of the hypothenuse, and the *complements* of the oblique angles, are called, in Napier's Rules, the *five circular parts* of a right-angled triangle; and if of these circular parts one of them be considered as the middle part, then the two parts immediately adjacent to it on the right and left are called the *adjoining extremes*, and the two remaining parts, each of which is separated from the middle part by an adjacent one, are called opposite extremes.

Thus in the spherical triangle A B C, right angled at B, if A B be considered as the middle part, the complement of A, and the side B C are the *adjoining extremes;* and the complements of A C, and the angle C, are the *opposite extremes.* If the complement of A be considered as the *middle part,* A B and the complement of A C are the *adjoining extremes;* and B C and the complement of C are the opposite extremes. If the complement of A C be considered as the *middle part,* the complements of the angles A and C are the *adjoining extremes,* and the sides A B and B C are the opposite extremes.

With these explanations of the terms, Napier's Rules for the solution of the different cases of right-angled spherical triangles are—

1. *The rectangle of radius and the sine of the middle part is equal to the rectangle of the tangents of the adjoining extremes.*

2. *The rectangle of radius and the sine of the middle part is equal to the rectangle of the cosines of the opposite extremes.*

If each of the circular parts be taken in succession as the middle one, we shall find that these two equations produce all the ten equations for right-angled spherical triangles demonstrated above. Thus, considering A B as the middle part, B C and the complement of A are the adjoining extremes; and the complements of A C and C are the opposite extremes. And the first of Napier's Rules gives,

rad . sin A B = tan B C . tan complement A, or tan B C . cot A. (Equation 1.)

The second of Napier's Rules gives

rad . sin A B = cos complement A C . cos complement C, or sin A C . sin C . (Equation 2.)

If the complement of C be the middle part, we have by Napier

rad . sin complement C = tan B C . tan complement A C

or rad . cos C = tan B C . cot A C. (Equation 9.)

and rad . sin complement C = cos A B . cos complement A

or rad . cos C = cos A B . sin A. (Equation 10.)

And in this manner may each of the above ten equations be shown to be the same with those produced by Napier's Rules, and the equations of Napier are therefore identical with those which have been directly demonstrated.

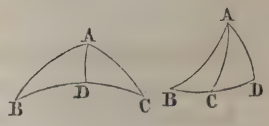
Proposition XVI.

In any spherical triangle the sines of the sides are proportional to the sines of their opposite angles.

In the right-angled spherical triangle A B C (see the last figure) we have (Prop. 15.) rad . sin A B = sin A C . sin B C A and rad . sin B C = sin A C . sin B A C; hence rad . sin A B : rad . sin B C

sin A C . sin B C A : sin A C . sin B A C ; or sin A B : sin B C : : sin B C A : sin B A C.

But if the triangle A B C be not right angled, let A D be a great circle drawn from A perpendicular to B C, or B C produced. Then in the right-angled triangle A D B we have R . sin A D = sin A B . sin B ; and in the right-angled triangle A D C we have R . sin A D = sin A C . sin C ; hence sin A B . sin B = sin A C . sin C ; or sin A B : sin A C : : sin C : sin B.



Proposition XVII.

In any oblique-angled spherical triangle A B C (*see the last figure*), *if* A D *be a perpendicular from* A *on* B C, *or* B C *produced, the following proportions obtain.*

Viz. 1. cos B D : cos D C : : cos A B : cos A C
2. cos B : cos C : : sin B A D : sin C A D
3. sin B D : sin D C : : cot B : cot C
4. cos B A D : cos C A D : : cot A B : cot A C
5. tan B D : tan D C : : tan B A D : tan C A D.

For Prop. 15, Equation 6, rad . cos A B = cos A D . cos B D ; and rad . cos A C = cos A D . cos D C, whence cos A D . cos B D : cos A D . cos D C : : rad . cos A B : rad . cos A C, or

cos B D : cos D C : : cos A B . cos A C. (Proportion 1.)

By Equation 8, Prop. 15, rad . cos B = cos A D . sin B A D ; and rad . cos C = cos A D . sin C A D.

Whence rad . cos B : rad . cos C : : cos A D . sin B A D : cos A D . sin C A D, or

cos B : cos C : : sin B A D : sin C A D. (Proportion 2.)

By Equation 1, Prop. 15, rad . sin B D = tan A D . cot B ; and rad . sin D C = tan A D . cot C.

Therefore rad . sin B D : rad . sin D C : : tan A D . cot B : tan A D . cot C

or, sin B D : sin D C : : cot B : cot C. (Proportion 3.)

By Equation 9, Prop. 15, rad . cos B A D = tan A D . cot A B ; and rad . cos C A D = tan A D . cot A C.

Therefore rad . cos B A D : rad . cos C A D : : tan A D . cot A B : tan A D . cot A C

or, cos B A D : cos C A D : : cot A B : cot A C. (Proportion 4.)

By Equation 3, Prop. 15, rad . sin A D = tan B D . cot B A D, and rad . sin A D = tan D C . cot C A D.

Whence tan B D . cot B A D = tan D C . cot C A D, or tan B D : tan D C : : cot C A D : cot B A D.

But cot C A D : cot B A D :: tan B A D : tan C A D. (Art. 5. page 67.)
Therefore tan B D : tan D C :: tan B A D : tan C A D. (Proportion 5.)

Proposition XVIII.

To investigate the relation between the cosine of an angle of a spherical triangle, and the sines and cosines of its sides.

Let A B C (see the last figure) be a spherical triangle, and A D a perpendicular from A on B C, or on B C produced. Then (Prop. 17.) cos A B : cos A C :: cos B D : cos D C. But when A D falls within the triangle D C = B C − B D, and when A D falls without the triangle D C = B D − B C. Now cos $\overline{\text{B C} - \text{B D}}$ is equal to cos $\overline{\text{B D} - \text{B C}}$, for each of them is equal to cos B C . cos B D + sin B C . sin B D (Form. 1. Prop. 3. Trig.); therefore cos A B : cos A C :: cos B D : cos B D . cos B C + sin B D . sin B C. Or dividing both the latter terms of the analogy by cos B D, we have cos A B : cos A C :: 1 : cos B C + $\frac{\sin \text{B D}}{\cos \text{B D}}$. sin B C. But $\frac{\sin \text{B D}}{\cos \text{B D}}$ = tan B D. Hence cos A B : cos A C :: 1 : cos B C + tan B D . sin B C. Now (Prop. 15.) rad . cos B = tan B D . cot A B; or tan B D = $\frac{\text{rad} . \cos \text{B}}{\cot \text{A B}} = \frac{\sin \text{A B} . \cos \text{B}}{\cos \text{A B}}$. Substituting this for tan B D in the above proportion, and multiplying each of the latter terms by cos A B, we have cos A B : cos A C :: cos A B : cos A B . cos B C + sin A B . sin B C . cos B.

Hence cos A C = cos A B . cos B C + sin A B . sin B C . cos B, or sin A B . sin B C . cos B = cos A C − cos A B . cos B C; whence

$$\cos \text{B} = \frac{\cos \text{A C} - \cos \text{A B} . \cos \text{B C}}{\sin \text{A B} . \sin \text{B C}}.$$

Cor. If the sides opposite the angles A, B, and C be respectively represented by the corresponding small letters a, b, and c, the above theorem will be expressed thus:

$$\cos \text{B} = \frac{\cos b - \cos a . \cos c}{\sin a . \sin c}.$$

By processes perfectly similar, like theorems may be deduced for cos A and cos C.

Hence

$$\cos \text{A} = \frac{\cos a - \cos b . \cos c}{\sin b . \sin c}; \quad \cos \text{B} = \frac{\cos b - \cos a . \cos c}{\sin a . \sin c};$$

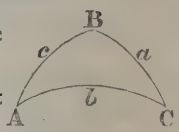
$$\cos \text{C} = \frac{\cos c - \cos a . \cos b}{\sin a . \sin b}.$$

Proposition XIX.

To investigate the trigonometrical relation between the sides of a spherical triangle, and the half of any of its angles.

Adopting the notation used in the resulting formulæ of the preceding proposition, if we take any of the angles as A, we have

$\cos A = \dfrac{\cos a - \cos b \,.\, \cos c}{\sin b \,.\, \sin c}$. But $1 + \cos A =$ $2\cos^2 \dfrac{A}{2}$ (Form. 4. Prop. 3. Trig.) Hence $2\cos^2 \dfrac{A}{2} =$



$1 + \dfrac{\cos a - \cos b \,.\, \cos c}{\sin b \,.\, \sin c} = \dfrac{\sin b \,.\, \sin c + \cos a - \cos b \,.\, \cos c}{\sin b \,.\, \sin c}$

$= \dfrac{\cos a - (\cos b \,.\, \cos c - \sin b \,.\, \sin c)}{\sin b \,.\, \sin c} = \dfrac{\cos a - \cos \overline{b + c}}{\sin b \,.\, \sin c}$ (Trig. Prop. 3. Form. 1.)

$= \dfrac{2 \sin \dfrac{a + b + c}{2} \,.\, \sin \dfrac{b + c - a}{2}}{\sin b \,.\, \sin c}$ (Trig. Prop. 3 Form. 3.) $=$

$\dfrac{2 \sin \dfrac{a + b + c}{2} \,.\, \sin\left(\dfrac{a + b + c}{2} - a\right)}{\sin b \,.\, \sin c}$. Or if S be put for $\dfrac{a + b + c}{2}$, we have $2\cos^2 \dfrac{A}{2} = \dfrac{2 \sin S \,.\, \sin \overline{S - a}}{\sin b \,.\, \sin c}$; or

$\cos^2 \dfrac{A}{2} = \dfrac{\sin S \,.\, \sin \overline{S - a}}{\sin b \,.\, \sin c}$, to radius unity, or $\cos^2 \dfrac{A}{2} =$

$\dfrac{\sin S \,.\, \sin \overline{S - a} \,.\, \text{rad} \,.\, \text{rad}}{\sin b \,.\, \sin c} = \dfrac{\sin S \,.\, \sin \overline{S - a} \,.\, \text{cosec}\ b \,.\, \text{cosec}\ c}{\text{rad}^2}$

or $\cos \dfrac{A}{2} = \sqrt{\dfrac{\sin S \,.\, \sin \overline{S - a} \,.\, \text{cosec}\ b \,.\, \text{cosec}\ c}{\text{rad}^2}}$

Again, as $1 - \cos A = 2 \sin^2 \dfrac{A}{2}$ (Form. 4. Trig.) we have $2 \sin^2 \dfrac{A}{2}$

$= 1 - \dfrac{\cos a - \cos b \,.\, \cos c}{\sin b \,.\, \sin c} = \dfrac{\sin b \,.\, \sin c - \cos a + \cos b \,.\, \cos c}{\sin b \,.\, \sin c}$

$= \dfrac{\cos b \,.\, \cos c + \sin b \,.\, \sin c - \cos a}{\sin b \,.\, \sin c} = \dfrac{\cos \overline{b - c} - \cos a}{\sin b \,.\, \sin c}$ (Trig. Prop. 3. Form. 1.)

$= \dfrac{2 \,.\, \sin \dfrac{a + b - c}{2} \,.\, \sin \dfrac{a + c - b}{2}}{\sin b \,.\, \sin c}$, (Trig. Prop. 3. Form. 3.) $=$

$\dfrac{2 \sin \left(\dfrac{a + b + c}{2} - c\right) \,.\, \sin\left(\dfrac{a + b + c}{2} - b\right)}{\sin b \,.\, \sin c}$. Or putting S, as

above, for $\frac{a+b+c}{2}$, we have $2\sin^2\frac{A}{2} = \frac{2\sin\overline{S-b}\cdot\sin\overline{S-c}}{\sin b\cdot\sin c}$;

and, by a reduction similar to the preceding, we obtain

$$\sin\frac{A}{2} = \sqrt{\frac{\sin\overline{S-b}\cdot\sin\overline{S-c}\cdot\operatorname{cosec} b\cdot\operatorname{cosec} c}{\text{rad}^2}}$$

By like processes, similar formulæ may be obtained for sin and cos of $\frac{B}{2}$ and $\frac{C}{2}$.

The formulæ for the half of *any* angle A may be thus arranged for the convenience of reference; A, B, and C representing the angles, a, b, and c their opposite sides, and S half the sum of the sides.

$$\sin\frac{A}{2} = \sqrt{\frac{\sin\overline{S-b}\cdot\sin\overline{S-c}\cdot\operatorname{cosec} b\cdot\operatorname{cosec} c}{\text{rad}^2}}$$

$$\cos\frac{A}{2} = \sqrt{\frac{\sin S\cdot\sin\overline{S-a}\cdot\operatorname{cosec} b\cdot\operatorname{cosec} c}{\text{rad}^2}}.$$

In logarithms these formulæ are

$$\log\sin\frac{A}{2} =$$

$$\frac{\log\sin\overline{S-b} + \log\sin\overline{S-c} + \log\operatorname{cosec} b + \log\operatorname{cosec} c - 20}{2}.$$

$$\log\cos\frac{A}{2} =$$

$$\frac{\log\sin S + \log\sin\overline{S-a} + \log\operatorname{cosec} b + \log\operatorname{cosec} c - 20}{2}.$$

Proposition XX.

In any spherical triangle, as A B C (*Fig. to Prop.* 16), *if* A D *be a perpendicular from* A *on* B C, *or on* B C *produced; then* $\tan\frac{BD+DC}{2} : \tan\frac{BA+AC}{2} :: \tan\frac{BA\sim AC}{2} : \tan\frac{BD\sim DC}{2}$.

For let A C $= b$, A B $= c$, C D $= m$, and B D $= n$

Then (Prop. 17. Spherics) $\cos b : \cos c :: \cos m : \cos n$; whence (Geo. Prop. 69.) $\cos b + \cos c : \cos b \sim \cos c :: \cos m + \cos n : \cos m \sim \cos n$; or (Prop. 3. Form. 9. Trig.)

$\cot\frac{b+c}{2} : \tan\frac{b\sim c}{2} :: \cot\frac{m+n}{2} : \tan\frac{m\sim n}{2}$; or (Geo. Prop. 68.)

$\cot\frac{b+c}{2} : \cot\frac{m+n}{2} :: \tan\frac{b\sim c}{2} : \tan\frac{m\sim n}{2}$; or (Trig. Art. 5. page 67) $\tan\frac{m+n}{2} : \tan\frac{b+c}{2} :: \tan\frac{b\sim c}{2} : \tan\frac{m\sim n}{2}$.

Cor. When the perpendicular A D falls within the triangle B D + D C $=$ B C, and when A D falls without the triangle B D $\sim$ D C $=$ B C,

the base. Therefore in the first case we have $\tan\frac{BC}{2} : \tan\frac{BA+AC}{2} :: \tan\frac{BA \sim AC}{2} : \tan\frac{BD \sim DC}{2}$; and in the second $\tan\frac{BC}{2} : \tan\frac{BA+AC}{2} :: \tan\frac{BA \sim AC}{2} : \tan\frac{BD+DC}{2}$.

Cor. By this proposition, an oblique-angled spherical triangle, whose sides are given, may be divided into two right-angled spherical triangles, in each of which the hypothenuse and a side will be given; and hence the angles of the triangles may be determined without reference to the formulæ in the last proposition.

Proposition XXI.

Adopting the notation in Prop. 19, *it is proposed to demonstrate the following expressions.*

$$\tan\frac{A+B}{2} = \frac{\cot\frac{C}{2} \cdot \sec\frac{a+b}{2} \cdot \cos\frac{a-b}{2}}{\text{rad}^2}$$

$$\tan\frac{A-B}{2} = \frac{\cot\frac{C}{2} \cdot \operatorname{cosec}\frac{a+b}{2} \cdot \sin\frac{a-b}{2}}{\text{rad}^2}$$

$$\tan\frac{a+b}{2} = \frac{\tan\frac{c}{2} \cdot \sec\frac{A+B}{2} \cdot \cos\frac{A-B}{2}}{\text{rad}^2}$$

$$\tan\frac{a-b}{2} = \frac{\tan\frac{c}{2} \cdot \operatorname{cosec}\frac{A+B}{2} \cdot \sin\frac{A-B}{2}}{\text{rad}^2}$$

From the formula for cos C, Prop. 18, we have

$$\cos c = \sin a \cdot \sin b \cdot \cos C + \cos a \cdot \cos b.$$

Substituting this for cos c, in the formula for cos A, in the same Prop., we have

$$\cos A = \frac{\cos a - \cos b \cdot \sin b \cdot \sin a \cdot \cos C - \cos a \cdot \cos^2 b}{\sin b \cdot \sin c} =$$

$$\frac{\cos a\,(1 - \cos^2 b) - \cos b \cdot \sin b \cdot \sin a \cdot \cos C}{\sin b \cdot \sin c} =$$

$$\frac{\cos a \cdot \sin^2 b - \cos b \cdot \sin b \cdot \sin a \cdot \cos C}{\sin b \cdot \sin c} =$$

$$\frac{\cos a \cdot \sin b - \cos b \cdot \sin a \cdot \cos C}{\sin c}, \text{ and by a similar process}$$

we have, $\cos B = \frac{\cos b \cdot \sin a - \cos a \cdot \sin b \cdot \cos C}{\sin c}$.

Whence $\cos A + \cos B = \dfrac{(\cos a \cdot \sin b + \sin a \cdot \cos b) \cdot \overline{1 - \cos C}}{\sin c} =$

$\dfrac{\sin \overline{a + b} \cdot 2 \sin^2 \dfrac{C}{2}}{\sin c}$ (Form. 1 and 4, Prop. 3, Trig.)

Again, as $\sin A : \sin B :: \sin a : \sin b$, therefore $\dfrac{\sin A \pm \sin B}{\sin B} =$

$\dfrac{\sin a \pm \sin b}{\sin b}$; or, $\sin A \pm \sin B = \dfrac{(\sin a \pm \sin b) \sin B}{\sin b}$.

Hence $\dfrac{\sin A + \sin B}{\cos A + \cos B} = \dfrac{\sin a + \sin b}{2 \cdot \sin \overline{a + b} \cdot \sin^2 \dfrac{C}{2}} \cdot \dfrac{\sin c \cdot \sin B}{\sin b}$.

But $\dfrac{\sin c \cdot \sin B}{\sin b} = \sin C = 2 \sin \dfrac{C}{2} \cdot \cos \dfrac{C}{2}$ (Trig., Prop. 3, Form. 4)

and $\dfrac{\sin A + \sin B}{\cos A + \cos B} = \tan \dfrac{A+B}{2}$ (Trig., Prop. 3, Form. 10.)

Hence $\tan \dfrac{A + B}{2} = \dfrac{\overline{\sin a + \sin b} \cdot 2 \sin \dfrac{C}{2} \cdot \cos \dfrac{C}{2}}{2 \sin \overline{a + b} \cdot \sin^2 \dfrac{C}{2}} =$

$\dfrac{2 \sin \dfrac{a + b}{2} \cdot \cos \dfrac{a - b}{2} \cdot \cos \dfrac{C}{2}}{2 \sin \dfrac{a + b}{2} \cdot \cos \dfrac{a + b}{2} \cdot \sin \dfrac{C}{2}} = \dfrac{\cos \dfrac{a - b}{2} \cdot \cot \dfrac{C}{2}}{\cos \dfrac{a + b}{2}} =$

$\dfrac{\cot \dfrac{C}{2} \cdot \sec \dfrac{a + b}{2} \cdot \cos \dfrac{a - b}{2}}{\text{rad}^2}$, the first equation.

Similarly, $\dfrac{\sin A - \sin B}{\cos A + \cos B} = \dfrac{\sin a - \sin b}{2 \sin \overline{a + b} \cdot \sin^2 \dfrac{C}{2}} \cdot \sin C.$

Whence, as above,

$$\tan \frac{A - B}{2} = \frac{\sin \dfrac{a - b}{2} \cdot \cot \dfrac{C}{2}}{\sin \dfrac{a + b}{2}} = \frac{\cot \dfrac{C}{2} \cdot \operatorname{cosec} \dfrac{a + b}{2} \cdot \sin \dfrac{a - b}{2}}{\text{rad}^2}$$

the second equation. And if, in the triangle supplemental to A B C, $180 - a$ be substituted for A, $180 - b$ for B, $180 - c$ for C, the above equations will be transformed into the third and fourth.

In applying these formulæ, it is proper to notice that $\dfrac{a + b}{2}$ and

$\frac{A+B}{2}$ are always of the same affection; and that $\frac{a-b}{2}$ and $\frac{A-B}{2}$ are always acute.

Proposition XXII.

When two sides of a spherical triangle, and the included angle, are given, to find the third side.

Let the given sides be b and c, the included angle A, and the opposite or required side be a. Then, (Prop. 18, Spherics,) $\cos A = \frac{\cos a - \cos b \,.\, \cos c}{\sin b \,.\, \sin c}$, whence $\cos a = \cos b \,.\, \cos c + \sin b \,.\, \sin c \,.\, \cos A$. But, from Form. 4, Plane Trig., page 72, we have $\cos a = 1 - 2\sin^2 \frac{a}{2}$, $\cos A = 2\cos^2 \frac{A}{2} - 1$, and $\cos \overline{b+c} = 1 - 2\sin^2 \frac{b+c}{2}$. Hence, from the above equation, we have $1 - 2\sin^2 \frac{a}{2} = \cos b \,.\, \cos c + \sin b \,.\, \sin c \left\{ 2\cos^2 \frac{A}{2} - 1 \right\} = \cos b \,.\, \cos c - \sin b \,.\, \sin c + \sin b \,.\, \sin c \,.\, 2\cos^2 \frac{A}{2} = \cos \overline{b+c} + 2 \,.\, \sin b \,.\, \sin c \,.\, \cos^2 \frac{A}{2} = 1 - 2 \,.\, \sin^2 \frac{b+c}{2} + 2 \,.\, \sin b \,.\, \sin c \,.\, \cos^2 \frac{A}{2}$. Or, $\sin^2 \frac{a}{2} = \sin^2 \frac{b+c}{2} - \sin^2 M \left(\sin^2 M \text{ being put for } \sin b \,.\, \sin c \,.\, \cos^2 \frac{A}{2} \right) = \left\{ \sin \frac{b+c}{2} + \sin M \right\} \,.\, \left\{ \sin \frac{b+c}{2} - \sin M \right\}$ (Geo. Theor. 43.) $= \sin \left\{ \frac{b+c}{2} + M \right\} \sin \left\{ \frac{b+c}{2} - M \right\}$. (Form. 6, Plane Trig., page 72.)

CONSTRUCTION AND USE OF THE MARINER'S SCALE.

The scale commonly used by mariners is two feet in length, and on one side of it are drawn several scales of equal parts, lines of natural sines, tangents, chords, &c.; and on the other side scales of the logarithmic relations of the numbers representing these lines.

The line marked Rum, or Rhumbs, exhibits the relative lengths of the chords to every point and quarter-point of the mariner's compass, or to every *thirty-second part* of the quadrant.

The lines of chords, sines, tangents, and secants exhibit the relative lengths of these lines to every degree of the quadrant; and the chord of 60° is the radius of the circle to which each of the scales is adapted.

The line of semitangents contains merely the tangents of half the

arcs marked on the line. Thus the semitangent of 20° is the tangent of 10°, &c.

On another part of the scale, a line of chords is generally given to a longer radius, accompanied with a line of rhumbs to the same radius. To this line of chords a line marked M. Lon. is also adapted, shewing the number of miles on any parallel of latitude, which corresponds to a degree of the terrestrial equator. Thus, opposite 40° on the line of chords stands nearly 46 on the line M. Lon.; which denotes that, on the parallel of 40°, 46 miles correspond to a degree of longitude.

The other parts of this side of the scale are generally filled up with lines of equal parts, of various lengths, marked L, P, Lea, and C; but the principal and most useful of these lines are two diagonal scales, of which the lengths of the largest divisions are an inch and half an inch, respectively.

The manner of using these diagonal scales will be readily understood from an example.

Let it be required to take the number 438 from a diagonal scale. Extend the compasses from 4 on the larger divisions to the third of the smaller ones; move one point of the compasses along the vertical line 4, and the other on the oblique line running from the third smaller division till they both come to the eighth parallel line; and the distance between the points of the compasses will be the measure of the required number on that scale.

The application of logarithms to a scale was first made by Mr. Edmund Gunter, and hence that side which is logarithmically divided is called *Gunter's Scale*. The first two lines, marked S. Rhumb and T. Rhumb, are divided according to the logarithmic relations of the sines and tangents, to every point and quarter-point of the compass; and the lines marked Sin and Tan are in fact the same lines as those marked S. Rhumb and T. Rhumb, but divided to degrees.

The tangents of arcs greater than half a right angle are placed and numbered backward on the same line with the tangents of their complements. For as $\frac{\text{rad}}{\tan} = \frac{\cot}{\text{rad}}$, therefore log rad − log tan = log cot − log rad. Now the tangent of half a right angle is equal to the radius; therefore the distance on the logarithmic scale, from the tangent of any less angle than half a right angle to the tangent of half a right angle, is the same as the distance from the tangent of half a right angle to the tangent of the complement of the proposed angle.

The tangents, therefore, which increase towards the left must be used as if they were placed on the scale continued towards the right from tangent 45°, or 4 points. The line marked *Num.* exhibits the relations between the logarithms of all numbers, of which the greatest does not exceed 100 times the least. As the difference between the logarithms

of 1 and 10 is the same as the difference between the logarithms 10 and 100, this scale is divided into two parts, which are perfectly equal, and similarly divided. Thus log 2·1 — log 1 = log 21 — log 10; therefore, the distance from the beginning to 2·1 is the same as that from 10, the middle of the scale, to 2, and one smaller division towards the right, or 21. If the 1 on the left hand be considered as 10, the 10 in the middle will represent 100, and the 10 on the right 1000. If the 1 on the right be considered as ·1, the 10 in the middle will represent 1, and the 10 on the right will represent 10; and in each case the intermediate divisions and parts of divisions have corresponding values.

The line of Versed Sines is not exactly what its title might import; it contains the logarithms of *half* the versed sines of the supplements of the arcs marked on it. Its chief use is to determine, by an instrumental operation, the angles of a plane or a spherical angle when the sides of it are given.

In the construction of the line of the logarithms of numbers, a line equal to the distance from 1 to 10 is taken, and decimally divided; and this whole line being considered as representing the logarithm of 10, those parts of it from 1, which correspond to the logarithms of the increasing integers, and the leading decimal parts, are taken and transferred to the scale. The various other logarithmic lines on this side of the scale are taken from the same decimal scale of equal parts that the line of the logarithms of numbers is formed from.

In constructing the line of *sines*, the difference between 10, the log sine of 90, and the logarithmic sine of any other angle, is taken from the decimal scale, and applied from 90° towards the left; and in constructing the line of *tangents*, the difference between 10, the log tangent of 45° and the log tangent of any other angle, is taken from the decimal scale, and applied from 45° towards the left; and the degrees are then marked at the points corresponding to them.

The line marked *versed sines* is formed by subtracting the logarithm of 2 from the log suversed sine of the given arc, and taking the remainder, for the parts of the required scale, from the same line of equal parts that the other scales are formed from.

The line marked *Mer.* exhibits the length of the meridian from the equator, according to Mercator's projection of the globe, in which projection the meridians are all parallel lines. The line below it, marked *E. parts*, or *equal parts*, shews the parts of the meridian, whose projection is shewn in the line above. These two lines are used jointly in forming a Mercator's chart; the line of *equal parts* being used to lay down the equator and the parallels of latitude, and the line of *Mer. parts* to project the meridians; but the lines are too small to be of much use in the practice of drawing charts.

The lines on the scale afford a ready method of obtaining, in a

rough way, a fourth proportional to three given numbers. And when, through the uncertainty of the data, a rough estimate of the result is all that can be obtained; or when, from the nature of the case, a very accurate result would be of no practical benefit, such results as can be obtained from the scale may be as useful as those deduced by methods which admit of greater precision.

The following general rule may be given for finding a fourth proportional by the scale.

If the first and second terms are of the same denomination, extend from the first term to the second, and that extent applied in the same direction will reach, on the proper line, from the third term to the required fourth proportional; or, if the first term and the third are of the same denomination, extend from the first term to the third, and that extent applied in the same direction will reach, on the appropriate line, from the second term to the fourth proportional.

Note. The tangents of arcs above 45°, which increase on the scale towards the left, must, *in estimating the direction*, be considered as continuing to increase from 45° *towards the right.*

Let it be required, by way of example, to find a fourth proportional to 34, 58, and 49,

Extend towards the right on the line of numbers from 34 to 58, and that extent applied from 49, also toward the right, on the same line, will reach to 83·6, the required fourth proportional.

Again, let it be required to find the arc whose sine is a fourth proportional to 484, 367, and sine of 51°. Extend towards the left from 484 to 367 on the line of numbers, and that extent applied on the line of sines towards the left, will reach from 51° to 36° 6′, the arc whose sine is the required fourth proportional.

Let us again inquire what that arc is, whose tangent is a fourth proportional to the sine of 26°, the sine of 78°, and the tangent of 40°.

Extend towards the right on the line of sines from 26° to 78°, and that extent applied from 40° on the line of tangents towards the right, will reach beyond the limits of the line. To find how much it reaches beyond the line, with the same extent in the compasses place one foot of them at 45°, then the other will extend towards the left as much beyond 40° as in the former case the extent went beyond the end of the line, and the distance between this point and 40° applied from 45° towards the left will reach to 61° 54′, the arc whose tangent is the required fourth proportional.

The use of the line of *versed sines* may be thus explained. We have found in plane trigonometry that S being half the sum of the sides of a triangle, of which the three sides are a, b, and c, and the angles opposite those sides A, B, and C, respectively, then

$$\frac{1 + \cos A}{2}, \text{ or } \frac{\text{suvers A}}{2} = \frac{\text{rad} \cdot S \cdot \overline{S - a}}{b \cdot c}.$$

And, adopting a like notation, we have in any spherical triangle,

$$\frac{1+\cos A}{2}, \text{ or } \frac{\text{suvers } A}{2} = \frac{\text{rad} \cdot \sin S \cdot \sin \overline{S-a}}{\sin b \cdot \sin c}.$$

Now the first of these equations, $\frac{\text{rad} \cdot S \cdot \overline{S-a}}{b \cdot c}$ may be resolved into the two following analogies, viz.

$$S : b :: c : \frac{bc}{S};$$

$$\text{and } \frac{bc}{S} : \overline{S-a} :: \text{rad} : \frac{\text{rad} \cdot S \cdot \overline{S-a}}{b \cdot c} = \frac{\text{suvers } A}{2}.$$

And the second equation, $\frac{\text{rad} \cdot \sin S \cdot \sin \overline{S-a}}{\sin b \cdot \sin c}$ may be resolved into the two following analogies, viz.

$$\text{rad} : \sin b :: \sin c : \frac{\sin b \cdot \sin c}{\text{rad}};$$

$$\text{and } \frac{\sin b \cdot \sin c}{\text{rad}} : \sin S :: \sin \overline{S-a} : \frac{\text{rad} \cdot \sin S \cdot \sin \overline{S-a}}{\sin b \cdot \sin c} = \frac{\text{suvers } A}{2}.$$

Hence to find, by the scale, any angle of a plane triangle whose sides are given, we have this rule.

Extend on the line of numbers from half the sum of the three sides to one of the sides containing the required angle, and that extent will reach, in the same direction, from the other side about the required angle to a fourth number. Extend from this fourth number to the difference between half the sum of the sides and the side opposite the required angle, and the extent will reach from 0° on the line of versed sines to the required angle.

And to find any angle of a spherical triangle whose three sides are given, we have this rule.

Extend on the line of sines from 90° to either of the sides about the required angle, and this extent will reach, in the same direction, on the line of sines, from the other side about the required angle to a fourth arc. Extend on the same line from this fourth arc to half the sum of the three sides of the triangle, and this extent applied in the same direction, and on the same line, will reach from the difference between half the sum of the three sides and the side opposite the required angle, to another point on the line, below which, on the line of versed sines, will stand the required angle.

Example 1. Given the three sides of a plane triangle 1267, 849, and 729, to find the angle opposite the greatest side.

1267
849
729
2)2845
1422 Half the sum of the three sides.
155 Difference between the half sum and the greatest side.

Extend then from 1422 to 849, and that extent will reach in the same direction from 729 to 435. Extend from 435 to 155, and that extent will reach from 0° on the line of versed sines, to about 106½°, the required angle.

Example 2. Given the three sides of a spherical triangle 43° 14′, 37° 28′, and 51° 20′, to find the angle opposite the least side.

37°	28′
43	14
51	20
2)132	2
66	1 Half the sum of the three sides.
28	33 Difference between the half sum and the least side.

Extend on the line of sines from 90° to 51° 20′, and that extent will reach in the same direction from 43° 14′ to 32° 20′ on the line of sines.

Extend from 32° 20′ to 66° 1′, and that extent will reach in the same direction from 28° 33′ to about 54½° on the line of sines, below which on the line of versed sines stands nearly 50¾°, the required angle.

Example 3. Let it be required to find the greatest angle of a spherical triangle whose three sides are 114° 28′, 121° 6′, and 88° 4′.

114°	28′
121	6
88	4
2)323	38
161	49 Half the sum of the three sides.
40	43 Difference between half the sum and the greatest side.

Extend on the line of sines from 90° to 65° 32′, the *supplement* of 114° 28′, and that extent will reach in the same direction from 88° 4′ to about 65½° on the line of sines. Extend from 65½° to 18° 11′, the supplement of 161° 49′, and that extent will reach, in the same direction, from 40° 43′ to about 13° on the line of sines, below which stands, on the line of versed sines, nearly 123½°, the required angle.

APPLICATION OF TRIGONOMETRY TO THE NUMERICAL COMPUTATION OF THE DIFFERENT PARTS OF RIGHT-ANGLED PLANE TRIANGLES.

That all the parts of a right-angled plane triangle may become determinate, three parts of it must be given; and, at least, one of these parts must be a side. Now the right angle is always a given quantity, therefore either two of the sides, or a side and one of the acute angles, must be given, before the other parts can be computed.

In Prop. 4 of the theory of Trigonometry, the following proportions have been deduced, which are sufficient for the solution of any case that can arise from considering different parts of the triangle as given.

1. Any side of a triangle is to the sine of its opposite angle, as any other side is to the sine of its opposite angle; and, conversely, the sine of any angle is to its opposite side, as the sine of any other angle is to its opposite side.

2. Either of the sides containing the right angle is to radius as the other side is to tangent of its opposite angle; and, conversely, radius is to either of the sides about the right angle, as the tangent of the angle opposite the other side is to that other side.

3. Either of the sides containing the right angle is to radius as the hypothenuse is to the secant of the acute angle adjacent to that side; and, conversely, radius is to either of the sides containing the right angle as the secant of the acute angle adjacent to that side is to the hypothenuse.

Remark. As each of the acute angles is the complement of the other, the cosine, cotangent, or cosecant of either of the angles may be substituted, in the above proportions, for the sine, tangent, or secant of the other.

The proportions will in general be most conveniently solved by logarithms; the logarithm of the first term taken from the sum of the logarithms of the second and third will leave the logarithm of the required result.

To the above proportions the following useful properties of right-angled plane triangles may be added.

1. The number representing the hypothenuse is equal to the square root of the sum of the squares of the numbers representing the other two sides. (Geo. Theo. 44.)

2. The number representing either of the sides is equal to the square root of the product of the sum and the difference of the numbers representing the hypothenuse and the other side. (Geo. Theo. 44. Cor.)

Example I.

In the right angle triangle A B C, given the hypothenuse A C 840·4, and the ∠ A 38° 16′, to find the other parts.

By Construction.

Draw the horizontal line A B, and make the angle A equal to about $38\frac{1}{4}°$, on A C from a scale of equal parts lay off 840·4, and from C let fall on A B the perpendicular B C, then A B and B C, measured on the scale of equal parts from which A C was taken, will be found respectively to be about 660 and 520.

By Calculation.

The angle C being the complement of the angle A, is 51° 44′.

To find A B.		*To find* B C.	
As radius	10·000000	As radius	10·000000
: A C 840·4	2·924486	: A C 840·4	2·924486
: : cos ∠ A 38° 16′ ..	9·894945	: : sine ∠ A 38° 16′..	9·791917
	12·819431		12·716403
: A B 659·8	2·819431	: B C 520·5	2·716403

By Gunter's Scale.

Extend on the line of sines, from rad or sine 90°, to 38° 16′; that extent applied on the line of numbers, from 840·4 towards the left, will reach to B C, 520·5. Again extend on the line of sines from rad to 51° 44′, the complement of the angle A, and that extent applied on the line of numbers from 840·4 towards the left, will reach to A B, 659·8.

By Inspection.

In Table 2, under 38°, and opposite 210, the fourth part of A C, in the column of *dist.*, we have 165·5, for the fourth part of A B, in the column of *lat.*, and 129·3 for the fourth part of B C, in the column of *dep.*

And under 39°, and opposite 210, we have 163·2 and 132·2 for the fourth part of A B and B C respectively. Hence

with the angle A 38° the fourth part of A B is 165·5, and of B C 129·3

39°	163·2	132·2
Difference for one degree	− 2·3	+ 2·9

Now the difference between 38° and the given angle is nearly a quarter of a degree. Hence $\frac{A\,B}{4}$ is nearly equal to $165·5 - \frac{2·3}{4}$, or

to 165·5 − ·6, or to 164·9; or A B = 659·6 nearly. And $\frac{B C}{4}$ is nearly equal to 129·3 + $\frac{2·9}{4}$, or to 129·3 + ·7 or to 130; or B C = 520·0 nearly.

Example II.

In the right angle triangle A B C (see the last figure), given the base A B 1214, and the angle A 51° 40′ 30″ to find the other parts.

By Construction.

Draw the horizontal line A B, and make it of the proposed length from any convenient scale of equal parts. Make the angle A of the given magnitude, and draw B C perpendicular to A B, meeting A C in C. Then A C, measured on the scale of equal parts from which A B was taken, will be found 1958, and B C, measured on the same scale, will be found 1536 nearly.

By Calculation.

To find A C.		*To find* B C.	
As radius	10·000000	As radius	10·000000
: A B 1214	3·084219	: A B 1214	3·084219
: : sec ∠ A 51° 40′ 30″	10·207523	: : tan ∠ A 51° 40′ 30″	10·102119
	13·291742		13·186338
: A C 1957·7	3·291742	: B C 1535·8	3·186338
As cos A 51° 40′ 30″.	9·792477	As cos A 51° 40′ 30″.	9·792477
: A B 1214	3·084219	: A B 1214.....	3·084219
: : rad.....	10·000000	:: sin ∠ A 51° 40′ 30″	9·894596
	13·084219		12·978815
: A C 1957·7.....	3·291742	: B C 1535·8.....	3·186338

By Gunter's Scale.

Extend on the line of sines from 38° 19′ 30″, the complement of the angle A, to radius, or sine of 90°; that extent applied on the line of numbers from 1214 towards the right will reach to A C 1958. Again, extend from radius, or, 45° on the line of tangents, to 51° 40′ 30″; that extent applied on the line of numbers from 1214 towards the right will reach to B C 1536.

By Inspection.

With the angle A considered as 51°, at the bottom of Table 2, and 121·4, the tenth part of A B, in the column of *lat.* we have in the columns of *dist.* and *dep.* about 193, and 150 for the corresponding parts of A C and B C. And taking 52° for the angle A, we have 197 and 155·2 nearly, for the tenth parts of A C and B C.

Hence with the angle A 51° we have A C 193 and B C 150

	52°	197	155·2
Difference for one degree		+ 4	+ 5·2

Now 40′ 30″ being about $\frac{2}{3}$ of a degree, we have the tenth part of A C = 193 + $\frac{2}{3}$ of 4 nearly, = 193 + 2·6 nearly = 195·6 nearly; whence A C = 1956 nearly. And the tenth part of B C = 150 + $\frac{2}{3}$ of 5·2 = 150 + 3·4 = 153·4; whence B C = 1534 nearly.

Examples for Exercise.

Let A B C (Fig. p. 105) represent any plane triangle, right-angled at B.

1. Given A C 73·26, ∠ A 49° 12′ 20″, required the other parts?
Answer, ∠ C 40° 47′ 40″, B C 55·46, and A B 47·87.
2. Given A B 469·34, and ∠ A 51° 26′ 17″, to find the other parts?
Answer, ∠ C 38° 33′ 43″, B C 588·7, and A C 752·9.
3. Given A B 493, and ∠ C 20° 14′, required the remaining parts?
Answer, ∠ A 69° 46′, B C 1338, and A C 1425.
4. Let A B = 331, ∠ A = 49° 14′, what are the other parts?
Answer, A C 506·9, B C 383·9, and ∠ C 40° 46′.
5. If A C = 45, and ∠ C = 37° 22′, what are the remaining parts?
Answer, A B 27·31, B C 35·76, and ∠ A 52° 38′.
6. Given A C 4264·3, and ∠ A 56° 29′ 13″, to find the remaining parts? Answer, A B 2354·4, B C 3555·4, and ∠ C 33° 30′ 47″.
7. If A B = 8372·1, and B C = 694·73, what are the other parts?
Answer, A C 8400·9, ∠ C 85° 15′, and ∠ A 4° 45′.
8. If A B be 63·4, and A C be 85·72, what are the other parts?
Answer, B C 57·7, ∠ C 47° 42′ and ∠ A 42° 18′.
9. Given A C 7269, and A B 3162, to find the other parts?
Answer, B C 6545·2, ∠C 25° 47′ 7″, and ∠A 64° 12′ 53″.
10. If A B = 621·3, and A C = 918·4, what are the remaining parts?
Answer, ∠ A 47° 26′, ∠ C 42° 34′, and B C 676·3.
11. If A C = 4184, and A B = 2632, what are the remaining parts?
Answer, B C 3252·4, ∠A 51° 1′ 8″, and ∠C 38° 58′ 52″.
12. If A B = 732·1, and ∠ A = 60° 10′ what are the other parts?
Answer, A C 1471·6, B C 1276·59, and ∠ C 29° 50′.
13. Let A C be 225, and B C be 90.37, required the other parts?
Answer, A B 206, ∠ A 23° 41′, and ∠ C 66° 19″.
14. Given ∠ A 70° 4′ 38″, and A B 67289, to find the remaining parts?
Answer, B C 185653, A C 197471, and ∠C 19° 55′ 22″.
15. Given ∠ C 88° 4′ 56″, and A C 7396·2, to find the remaining parts?
Answer, B C 247·5, A B 7392, and ∠ A 1° 55′ 4″.
16. Given A C 631·25, B C 74·9, to find the other parts?
Answer, A B 626·8, ∠ A 6° 48′ 52″, and ∠C 83° 11′ 8″.

APPLICATION OF TRIGONOMETRY TO THE NUMERICAL COMPUTATION OF THE DIFFERENT PARTS OF OBLIQUE-ANGLED PLANE TRIANGLES.

That the different parts of an oblique-angled plane triangle may be computed, all the sides, two angles and a side, or two sides and an angle, must be given. Now when two of the angles are given, the third, which is the supplement of their sum, is known; hence, in that case, all the angles, and a side opposite to one of them, are given, to determine the other two sides. When one of the angles is given, the supplement of it, which is the sum of the other two, is known; therefore when one of these other angles is determined, the remaining angle is obtained at once.

The formulæ which have been demonstrated in the theory of trigonometry furnish the following rules for the solution of the different cases.

1. *When two sides and an angle opposite to one of them, or two angles and a side, are given.*

As any side of a triangle is to the sine of its opposite angle, so is any other side of the triangle to the sine of its opposite angle; and as the sine of any angle of a triangle is to its opposite side, so is the sine of any other angle of the triangle to its opposite side.

Note. When in the first of the foregoing proportions the less of the given sides is opposite to the given angle, the angle determined from the proportion may be either acute or obtuse, and the problem solved is then said to be ambiguous. But as the angles of every triangle are acute, which are opposite the least two of the sides, when the greater of the given sides is opposite the given angle, the angle determined from the proportion must be acute, and therefore in that case the problem is not ambiguous.

2. *When two sides and the contained angle are given.*

If a perpendicular be demitted from the extremity of one of the given sides, upon the other, or the other produced, the solution of the problem may be effected by computing the parts of the two right-angled triangles, which will be formed by the perpendicular and the sides of the triangle; and the computation will be facilitated by applying this property of oblique-angled triangles, demonstrated as Prop. 6, Trigonometry—viz., the segments of the base are to each other as the contangents of their adjoining angles. Or the angles opposite the given sides may be determined as follows.

As the sum of the given sides is to their difference, so is the tangent

of half the sum of their opposite angles to the tangent of half the difference of the same angles. (Trig. Prop. 7.)

And this half difference of the angles added to half their sum gives the angle opposite the greater side, and subtracted, leaves the angle opposite to the less side.

Then, the angles being known, the required side is obtained by the appropriate analogy in the first case.

3. *When the three sides are given to find the angles.*

Rule 1. As the base, or longest side, is to the sum of the other two sides, so is the difference of those sides to the difference of the segments of the base, made by a perpendicular from the opposite angle. (Trig. Prop. 8.) Then the half difference, added to half the base, gives the segment of it adjacent to the greater of the other two sides ; and subtracted, leaves the segment of it adjacent to the less side.

The triangle is thus divided into two right-angled triangles, in each of which the hypothenuse and one of the other sides are given ; whence the angles may be computed by the preceding rules.

But the angles may be otherwise determined from the sides by the following rules, deduced from the logarithmic formulæ, at page 79.

Rule 2. From half the sum of the three sides of the triangle subtract the side opposite the required angle. Then to the logarithms of the half sum and remainder add 20, and from that sum subtract the sum of the logarithms of the sides including the required angle, and half the remainder will be the logarithm *cosine of half the required angle.*

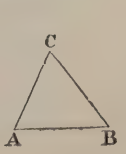
Rule 3. From half the sum of the three sides of the triangle subtract each of the sides including the required angle ; then to the logarithms of the two remainders add 20, and from the sum subtract the sum of the logarithms of the sides containing the angle, and half the remainder will be the logarithm *sine of half the required angle.*

As a small arc can be found more correctly by even proportion from its *sine* than its *cosine*, and an arc near the termination of the quadrant can be found more correctly from its *cosine* than its *sine*, the former of the rules for determining *half* the angle of a triangle may be applied in preference, when the half angle to be computed exceeds half a right angle, and the latter when the required half angle is less than half a right angle.

Example I.

In the triangle A B C, given A B 376, the angle A 48° 3′, and the angle B 40° 14′, to find the other parts.

The angle C, being the supplement of the sum of A and B, is 91° 43′.



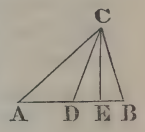
To find A C.		*To find* B C.	
As sin C 91° 43′	9·999805	As sin C 91° 43′	9·999805
: A B 376	2·575188	: A B 376.....	2·575188
: : sin B 40° 14′	9·810167	: : sin A 48° 3′.....	9·871414
	12·385355		12·446602
: A C 243	2·385550	: B C 279·8	2·446797

Example II.

Given two sides of a triangle, 654 and 460, and the angle opposite to the less of these sides 35° 12′, to find the other parts.

By Construction.

Make B A C equal to the given angle, and A C equal to the longer of the given sides. With C as a centre, and the length of the shorter of the given sides as a radius, cut A D B n B and D; join C D, C B; then both the triangles A C B, A C D, correspond with the given data; this being what has been noticed as the ambiguous case in the solution of oblique-angled plane triangles.



By Calculation.

C D being equal to C B, the angles C D B and C B D are equal; hence the angle A C D, which is the difference of the angles C D B and C A B, is the difference of the angles C B D and C A B; and the angle A C B is the supplement of the sum of A and B.

To find the angle B.

As B C 460	2·662758
: sin A 35° 12′	9·760748
: : A C 654	2·815578
	12·576326
: sin B 55° 2′	9·913568

Angle B 55° 2′, supplement 124° 58′ = angle A D C
angle A 35 12

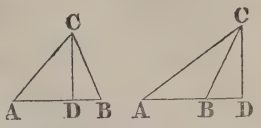
sum 90 14, supplement 89 46 = angle A C B

differ 19 50, angle A C D

To find A B.		*To find* A D.	
As sin B 55° 2′	9·913568	As sin A D C 124° 58′	9·913568
: A C 654	2·815575	: A C 654	2·815575
: · sin A C B 89° 46′..	9·999996	: : sin A C D 19° 50′.	9·530565
	12·815571		12·346140
A B 798	2·902003	: A D 270·8	2·432572

Example III.

In the triangle A B C are given A B 848, A C 534, and the included angle A 31° 17′, to find the other parts.



Let C D (see the first of the annexed figures) be a perpendicular from C upon A B, then in the right-angled triangle A D C we have

As radius.....	10·000000
: A C 534	2·727541
: : cos A 31° 17′	9·931768
: A D 456·4	2·659309
A B 848·0	
B D 391·6	

And in the triangle A B C, as A D 456·4..... 2·659309

: D B 391·6.....	2·592843
: : cot A 31° 17′....	10·216374
	12·809217
: cot B 35° 18′....	10·149908

A 31° 17′

66 35, sup 113° 25′ ∠ A C B

As sin B 35° 18′	9·761821
: A C	2·727541
: : sin A 31° 17′.....	9·715394
	12·442935
: B C 479·9	2·681114

Or the angles A C B and A B C may be found thus,

As A B + A C	1382	3·140508
: A B − A C	314	2·496930
: : tan $\frac{\text{sup A}}{2}$, or tan $\frac{\text{A C B} + \text{A B C}}{2}$,	74° 21½′	10 552859
		13·049789
: tan $\frac{\text{A C B} - \text{A B C}}{2}$,	39 3½	9·909281

A C B 113 25 sum

A B C 35 18 diff.

Having the angles, the side B C may be found as above.

Example IV.

In the triangle A B C (see the first figure on the last page) are given A B 757, A C 586, and B C 649, to find the angles.

First Method of Solution.

As A B 757	2·879096
: B C + A C 1235	3·091667
: : B C − A C 63	1·799341
	4·891008
: B D − A D 102·781	2·011912

$$\text{Whence } BD = \frac{BD + AD}{2} + \frac{BD - AD}{2} = 429{\cdot}89,$$

$$\text{and } AD = \frac{BD + AD}{2} - \frac{BD - AD}{2} = 327{\cdot}11.$$

To find the angle A.		*To find the angle* B.	
A C 586	2·767898	As B C 649	2·812245
: rad	10·000000	: rad	10·000000
: : A D 327·11	2·514693	: : D B 429·89	2·633356
: cos A 56° 4′ 5″	9·746795	: : cos B 48° 31′ 5″ ..	9·821111

And ∠ A C B is the supplement of A + B, or 75° 24′ 50″.

∠ A *found by the Second Rule.*

A B 757	log	2·879096
B C 649		
A C 586	log	2·767898
2)1992		5·646994
996	log	2·998259
347	log	2·540329
constant	log	20·
		25·538588
		2)19·891594
28° 2′ 3″	cos	9·945797
2		
56 4 6		∠ A

$\angle$ B *found by the Third Rule.*

A B 757	log	2·879096
B C 649	log	2·812245
A C 586		5·691341
2)1992		
996		
239	log	2·378398
347	log	2·540329
constant	log	20·
		24·918727
		2)19·227386
24° 15′ 32″	sin	9·613693
2		
48 31 4	$\angle$ B	

Examples for Exercise.

Let A B C (see figure, p. 109) represent any oblique-angled triangle.

1. Given A B 697, $\angle$ A 81° 30′ 10″, and $\angle$ B 40° 30′ 44″, to find the other parts?

Answer, A C 534, B C 813, and $\angle$ C 57° 59′ 6″.

2. If A C = 720·8, $\angle$ A = 70° 5′ 22″, and $\angle$ B = 59° 35′ 36″, required the other parts?

Answer, A B 643·2, B C 785·8, and $\angle$ C 50° 19′ 2″.

3. Given A B 896·2, B C 328·4, and $\angle$ C 113° 45′ 20″, to find the other parts?

Answer, A C 712, $\angle$ A 19° 35′ 46″, and $\angle$ B 46° 38′ 54″.

4. Given A C 4627, B C 5169, and $\angle$ A 70° 25′ 12″, to find the other parts?

Answer, A B 4328, $\angle$ B 57° 29′ 55″, and $\angle$ C 52° 4′ 53″.

5. Given A B 6·216, B C 7·853, and $\angle$ A 77° 34′ 40″, to find the other parts?

Answer, A C 6·319, $\angle$ B 51° 47′ 50″, and $\angle$ C 50° 37′ 30″.

6. Given A C 627, A B 430, and $\angle$ C 42° 53′ 38″, to find the other parts?

Answer, $\angle$ A 54° 8′ 26″, or 40° 4′ 18″, $\angle$ B 82° 57′ 56″, or 97° 2′ 4″, and B C 512, or 406·7.

7. Given A B 718, B C 629, and $\angle$ A 29° 52′ 34″, to find the other parts?

Answer, $\angle$ C 34° 39′ 11″, or 145° 20′ 49″, $\angle$ B 115° 28′ 15″, or 4° 46′ 37″, and A C 1140, or 105·1.

8. Given A C 484·2, A B 968·4, and $\angle$ A 75° 31′ 21″, to find the other parts?

Answer, B C 968·4, $\angle$ B 28° 57′ 18″, and $\angle$ C 75° 31′ 21″.

9. Given A B 1234·5, B C 620·8, and $\angle$ B 138° 39′ 8″, to find the other parts?

Answer, A C 1749·3, $\angle$ A 13° 33′ 34″, and $\angle$ C 27° 47′ 18″.

10. Given A C 72·48, B C 60·2, and $\angle$ C 31° 1′ 10″, to find the other parts?

Answer, A B 37·4, $\angle$ A 56° 2′ 45″, and $\angle$ B 92° 56′ 5″.

11. Given A B 912·4, B C 639·7, and A C 428·5, to find the angles?

Answer, $\angle$ A 39° 5′ 36″, $\angle$ B 24° 59′ 8″, and $\angle$ C 115° 55′ 16″.

12. Given A B 793·8, B C 481·6, and A C 500·0, to find the angles?

Answer, $\angle$ A 35° 15′ 32″, $\angle$ B 36° 49′ 18″, and $\angle$ C 107° 55′ 10″.

13. Given A B 92·6, B C 46·3, and A C 71·2, to find the angles?

Answer, $\angle$ A 29° 17′ 22″, $\angle$ B 48° 47′ 30″, and $\angle$ C 101° 55′ 8″.

14. Given A B 728·1, B C 614·7, and A C 583·8, to find the angles?

Answer, $\angle$ A 54° 32′ 52″, $\angle$ B 50° 40′ 58″, and $\angle$ C 74° 46′ 10″.

15. Given A B 363·4, B C 148·4, and $\angle$ B 102° 18′ 27″, to find the other parts?

Answer, $\angle$ A 20° 9′ 17″, A C 420·8, and $\angle$ C 57° 32′ 16″.

16. Given A B 632, B C 494, and $\angle$ A 20° 16′, to find the other parts, C being acute?

Answer, $\angle$ C 26° 18′ 19″, $\angle$ B 133° 25′ 41″, and A C 1035·72.

17. Given A B 2163, B C 1672, and $\angle$ C 112° 18′ 22″, to find the other parts?

Answer, A C 877·2, $\angle$ B 22° 2′ 16″, and $\angle$ A 45° 39′ 22″.

18. Given A B 428, $\angle$ C 49° 16′, and $\overline{\text{A C} + \text{B C}}$ 918, to find the other parts, $\angle$ B being obtuse?

Answer, $\angle$ A 38° 44′ 48″, $\angle$ B 91° 59′ 12″, A C 564·49, and B C 353·5.

19. Given A C 126, $\angle$ B 29° 46′, and $\overline{\text{A B} - \text{B C}}$ 43, to find the other parts?

Answer, $\angle$ A 55° 51′ 32″, $\angle$ C 94° 22′ 28″, A B 253·05, and B C 210·05.

20. Given A B 821·9, A C 640·3, and $\angle$ A 80° 24′, to find the other parts?

Answer, $\angle$ B 41° 26′ 21″, $\angle$ C 58° 9′ 39″, and B C 953·928.

21. Given A C 29674, B C 31283, and $\angle$ C 121° 5′ 38″, to find the other parts?

Answer, $\angle$ A 30° 18′ 25″, $\angle$ B 28° 35′ 57″, and A B 53084·5.

APPLICATION OF THE PRINCIPLES OF TRIGONOMETRY TO THE DETERMINATION OF THE HEIGHTS AND DISTANCES OF REMOTE OR INACCESSIBLE OBJECTS.

In this useful application of trigonometry, a base line is always supposed to be measured, or given in length; and by means of a quadrant, sextant, circle, theodolite, or some other instrument for measuring angles, such angles are measured in connection with the base line, and the objects whose heights or distances it is proposed to determine, as enable us to compute, from the principles of trigonometry, what those heights or distances are.

Sometimes, particularly in marine surveying, horizontal angles are determined by the compass; but the varying effect of surrounding bodies on the needle, even in situations little removed from each other, and the general construction of the instrument itself, render it unfit to be applied in the determination of angles where anything like precision is required.

The following examples present sufficient variety to guide the student in determining what will be the most eligible mode of proceeding in any case that is likely to occur in practice.

Example I.

Wanting to know the distance of an inaccessible object C (see figure, p. 109), I measured a base A B of 486 yards. At A, I found the angle C A B subtended by the object, and the other end of the line, to be 88° 12′; and at B the angle C B A was observed to be 54° 48′; required the distance of the object from each of the stations A and B?

The sum of the angles A and B is 143°, which, taken from 180°, leave 37° for the angle C. Hence,

sin ∠ C 37°	9·779463	sin ∠ C 37°	9·779463
: A B 486 yards...	2·686636	: A B 486 yards ...	2·686636
:: sin ∠ A 88° 12′..	9·999786	:: sin ∠ B 54° 48′.	9·912299
	12·686422		12·598935
: B C 807·2 yards	2·906959	: A C 659·9 yards	2·819472

Example II.

Being desirous of finding the distance between two distant objects, C and D, I measured a base A B of 384 yards, on the same horizontal

plane with the objects C and D. At A, I found the angle D A B = 48° 12′, and C A B = 89° 18′; at B the angle A B C was 46° 14′, and A B D 87° 4′; it is required from these data to compute the distance between C and D?

From the angle C A B take the angle D A B, the remainder, 41° 6′, is the angle C A D. To the angle D B A add the angle D A B, and 44° 44′, the supplement of the sum, is the angle A D B. In the same way the angle A C B, which is the supplement of the sum of C A B and C B A, is found to be 44° 28′.

Hence, in the triangles A B C and A B D, we have,

sin A C B 44° 28′ . .	9·845405	sin A D B 44° 44′ .	9·847454
: A B 384 yards . . .	2.584331	: A B 384 yards . . .	2·584331
: : sin A B C 46° 14′	9·858635	: : sin A B D 87° 4′	9·999431
	12·442966		12·583762
: A C 395·9 yards	2·597561	: A D 544·9 yards	2·736308

Then, in the triangle C A D, we have given the sides C A and A D and the included angle C A D, to find C D; to compute which we proceed thus:

The supplement of ∠C A D is the sum of the angles A C D and A D C; hence $\frac{A C D + A D C}{2} = 69° 27'$, and, by proportion, we have,

As A D + A C	940·8	2·973497	
: A D − A C	149	2·173186	
: : tan $\frac{A C D + A D C}{2}$	69° 27′	10·426108	
		12·599294	
: tan $\frac{A C D - A D C}{2}$	22 54	9·625797	
∠A C D	sum	92 21	
∠A D C	diff.	46 33	

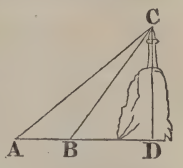
As sin A D C 46° 33′	9·860922
: A C	2·597561
: : sin C A D 41° 6′	9·817813
	12·415374
: C D 358·5 yards	2·554452

Example III.

To determine the altitude of a lighthouse, I observed the elevation of its top above the level sand on the seashore to be 15° 32′ 18″,

and measuring directly from it along the sand 638 yards, I then found its elevation to be 9° 56′ 26″; required the height of the lighthouse?

Let C D represent the height of the lighthouse above the level of the sand, and let B be the first station, and A the second; then the angle C B D is 15° 32′ 18″, and the angle C A B is 9° 56′ 26″; therefore the angle A C B, which is the difference of the angles C B D and C A B, is 5° 35′ 52″. Hence

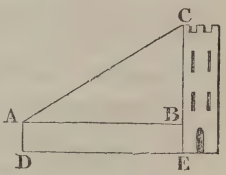


sin A C B 5° 35′ 52″	8·989201	radius	10.000000
: A B 638	2·804821	: B C 1129·06	3·052727
:: sin ∠ A 9° 56′ 26″	9·237107	:: sin C B D 15° 32′ 18″	9·427945
	12·041928		12·480672
: B C 1129·06 yards	3·052727	: D C 302·46 yards ..	2.480672

Example IV.

Wanting to know the height of a steeple, I measured 210 yards from the bottom of it, and then found the elevation of its top above the level of my instrument to be 33° 28′ 40″: required its height, the instrument standing five feet above the ground?

Let C E represent the steeple, D E the ground, and A D the instrument. Draw A B parallel to D E, then A B and D E will be equal, and B E will be equal to A D, the height of the instrument.



Now in the right-angled triangle A B C, there are given A B, 210 yards, and the angle B A C 33° 28′ 40″. Hence

As radius	10·000000
: A B 210 yards	2·322219
:: tan B A C 33° 28′ 40″..	9·820417
	12·142636
: B C 138·38	2·142636
B E 5	
The required height	143·38

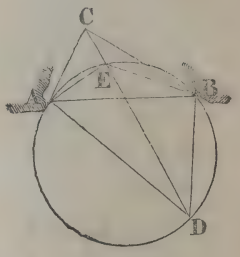
Example V.

Coming from sea, at the point D I observed two headlands, A and B, and inland at C a steeple, which appeared between the headlands; I found from a map that the headlands were 5·35 miles from each other, that the distance from A to the steeple was 2·8 miles, and from

B to the steeple 3·47 miles; and I found with a sextant, that the angle A D C was 12° 15′, and the angle B D C 15° 30′: required my distance from each of the headlands, and from the steeple.

By Construction.

On A C describe the segment of a circle, to contain the angle A D C (Prob. 13, Geo.); and on B C describe the segment of a circle to contain the angle B D C; and these circles will intersect in D, the place of the ship.



By Calculation.

Let A D B be the segment of a circle described on A B to contain the sum of the two given angles. Join D C, and let it meet the circumference of the circle in E, and join A E, B E. Then the angles E A B, E D B, being in the same segment, are equal to each other; and so, for the same reason, are the angles A B E and A D E. Hence, in the triangle A B E, all the angles and the side A B are given to find the side A E; and as all the sides of the triangle A B C are given, the angle B A C may be computed; and the difference of the angles B A C and B A E is the angle C A E, which, therefore, becomes known.

Now, in the triangle C A E, the two sides A C and A E, and the included angle C A E being known, the angle C may be determined; and hence, as the angle A D C is given, the angle C A D is known, and consequently B A D, the difference of C A D and C A B, is known. Hence all the angles of the triangle A D C and the side A C are given, whence A D and C D become known; and A B being known, as well as the angles B A D, B D A, of the triangle A B D, the side B D is also determined.

The computation at length is as follows:—

To find A E.

∠ E A B	15° 30′	As sin A E B 152° 15′	9·668027
∠ E B A	12 15	: A B 5·35	·728354
	27 45	:: sin A B E 12° 15′	9·326700
	180 0		10·055054
∠ A E B	152 15	: A E 2·438	·387027

To find the angle B A C.

B C	3·47		
A B	5·35	log	·728354
A C	2·80	log	·447158
	2)11·62		1·175512
	5·81	log	·764176
	2·34	log	·369216
			20
			21·133392
			2)19·957880
	17° 41′ 58″	cos	9·978940
	2		
∠ B A C	35 23 56		
∠ E A B	15 30		
∠ E A C	19 53 56		
	180		
	2)160 6 4		A E C + A C E / 2
	80 3 2		

To find the angles A E C *and* A C E.

As A C + A E		5·238	·719165
: A C − A E		·362	− 1·558709
:: tan $\frac{A E C + A C E}{2}$	80° 3′ 2″		10·755928
			10·314637
: tan $\frac{A E C - A C E}{2}$	21 30 12		9·595472

∠ A E C	101 33 14	sum
∠ A C E or A C D	58 32 50	diff.
∠ C D A	12 15	
	70 47 50	supplement

109° 12′ 10″	∠ C A D	
35 23 56	∠ C A B	
73 48 14	∠ B A D	

To find A D.

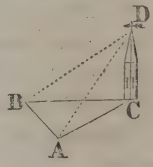
As sin A D C 12° 15′	9·326700
: A C 2·8	·447158
:: sin A C D 58° 32′ 50″ ...	9·930985
	10·378143
: A D 11·26 miles	1·051443

To find C D.		*To find* B D.	
sin A D C 12° 15″	9·326700	sin A D B 27° 45′	9·668027
: A C 2·8	·447158	: A B 5·35	0·728354
:: sin C A D 109° 12′ 10″	9·975138	:: sin B A D 73° 48′ 14″	9·982412
	10·422296		10·710766
: C D 12·46 miles ...	1·095596	: B D 11·03 miles ...	1·042739

Example VI.

The elevation of a spire at one station was 23° 50′ 17″, and the horizontal angle at this station between the spire and another station was 93° 4′ 20″; the horizontal angle at the latter station between the spire and the first station was 54° 28′ 36″, and the distance between the two stations 416 feet, required the height of the spire?

Let C D be the spire, A the first station, and B the second; then the vertical angle C A D is 23° 50′ 17″, and as the horizontal angles C A B and C B A are 93° 4′ 20″, and 54° 28′ 36″ respectively; the angle A C B, the supplement of their sum, is 32° 27′ 4″.



To find A C.		*To find* D C.	
sin B C A 32° 27′ 4″ ..	9·729634	radius	10·000000
: side A B 416	2·619093	: side A C 631	2·800019
:: sin A B C 54° 28′ 36″	9·910560	:: tan D A C 23° 50′ 17″	9·645270
	12·529653	side D C 278·8	2·445289
: side A C 631	2·800019		

Examples for Exercise.

1. Required the height of a wall, whose angle of elevation is observed, at the distance of 463 feet, to be 16° 21′.

Answer, 135·8 feet.

2. The angle of elevation of a hill is, near its bottom, 31° 18′, and 214 yards farther off, 26° 18′, required the perpendicular height of the hill, and the distance of the perpendicular from the first station?

Answer, the height of the hill is 565·2, and the distance of the perpendicular from the first station is 929·6.

3. The wall of a tower which is 149·5 feet in height, makes, with a line drawn from the top of it to a distant object on the horizontal plane, an angle of 57° 21′, what is the distance of the object from the bottom of the tower? Answer, 233·3 feet.

4. From the top of a tower, whose height was 138 feet, I took the angles of depression of two objects which stood in a direct line from the bottom of the tower, and upon the same horizontal plane with it.

The depression of the nearer object was found to be 48° 10′, and that of the farther 18° 52′, what was the distance of each from the bottom of the tower?

Answer, distance of the nearest 123·5, and of the farthest 403·8 feet.

5. Being on the side of a river, and wishing to know the distance of a house on the other side, I measured 312 yards in a right line by the side of the river, and then found that the two angles, one at each end of this line, subtended by the other end and the house, were 31° 15′ and 86° 27′, what was the distance between each end of the line and the house? Answer, 351·7 and 182·8 yards.

6. Having measured a base of 260 yards in a straight line, close by one side of a river, I found that the two angles, one at each end of the line, subtended by the other end and a tree close to the opposite bank, were 40° and 80°, what was the breadth of the river?

Answer, 190·1 yards.

7. From a ship a headland was seen, bearing N E ½ N, the vessel then stood away N W ¼ W 20 miles, and the same headland was observed to bear from her E ¼ N, required the distance of the headland from the ship at each station?

Answer, distance at the first station 19·09, and at the second 26·96 miles.

8. A cape was observed to bear from us N W, and another headland to bear N N E ½ E; standing away E N E ½ E 23 miles, we found the first bore from us W N W, and the second N b W ½ W, required the bearing and distance of the cape from the headland?

Answer, S 87° 40′ W 42·33 miles.

9. From an eminence of 268 feet in perpendicular height, the angle of depression of the top of a steeple which stood on the same horizontal plane was found to be 40° 3′, and of the bottom 56° 18′, what was the height of the steeple? Answer, 117·8 feet.

10. Wanting to know the distance between two objects which were separated by a morass, I measured the distance from each to a point where I could see them both; the distances were 1840 and 1428 yards, and the angle which, at that point, the objects subtended, was 36° 18′ 24″, required their distance? Answer, 1090·85 yards

11. From the top of a mountain, 3 miles in height, the visible horizon appeared depressed 2° 13′ 27″, required the diameter of the earth, and the distance of the boundary of the visible horizon?

Answer, diameter of the earth 7958 miles, distance of horizon 154·54 miles.

12. A statue 12 feet high stands on the top of a column, whose height is 48 feet above the level of the eye, at what distance from the base of the column, on the same horizontal plane, will the statue appear under the greatest possible vertical angle, and what will that angle be? Answer, distance 53·6656 feet, angle 6° 22′ 46″.

13. Wanting to know the distance of two objects, A and B, from each other, and from another object D, all in the same horizontal plane, in B A produced on the side of A, a point C was taken, and C D being measured was found to be 549·36 yards, and the angle C 57°. At D, the angle C D A was observed to be 14°, and the angle B D A 41° 30′, required the distances of A, B, and D from each other? Answer, A B 349·52, A D 487·27, and B D 498·69 yards.

APPLICATION OF THE FORMULÆ INVESTIGATED IN THE ELEMENTARY PRINCIPLES OF SPHERICAL TRIGONOMETRY, TO THE NUMERICAL COMPUTATION OF THE MEASURES OF THE SIDES AND ANGLES OF RIGHT-ANGLED SPHERICAL TRIANGLES.

Spherical triangles present six parts for consideration, three sides and three angles; but in right-angled triangles the measure of the right angle can never be the subject of inquiry: therefore the sides, the hypothenuse, and the two oblique angles, are all the parts of the triangle to which it is necessary to advert; and any two of these being given, the others may be computed.

Now if *three* of these five parts be taken, one of the three will either lie between the other two, or be separated from them by the two remaining parts of the triangle. This part is called the *middle part;* and, when it is adjacent to the other two parts, they are called, with respect to it, the *adjoining extremes;* otherwise, they are called the *opposite extremes.*

With this understanding respecting the denominations of the different parts, as *middle* or *extreme*, let the sides about the right angle, the *complement* of the hypothenuse, and the *complements* of the oblique angles, be considered as the five circular parts, then the two following equations, called Napier's Rules for the Circular Parts, obtain universally, and they are sufficient for the solution of any case that can arise from considering different parts of the triangle as given.

1. *Radius* × *sine of the middle part* = *rectangle of the tangents of the adjoining extremes.*

2. *Radius* × *sine of the middle part* = *rectangle of the cosines of the opposite extremes.*

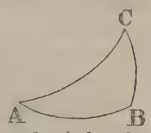
In the solution of problems, there will in every case be two parts given and one required; hence, in applying these equations, of the three quantities concerned take that as the middle part which is either adjacent to the other two, or is separated from them both by the remaining parts of the triangle, and observe whether the other parts become *adjoining* or *opposite* extremes, and form the equation accordingly. Transform the equation into a proportion (Geo. Prop. 73), so

that the required term may be the last; and, on solving this proportion, the required term will be obtained.

For example, in the triangle A B C let the hypothenuse A C and the angle A be given to find the other parts.

To find B C.

Here of the three parts A C, ∠ A, and B C, A C cannot be the middle part, for the angle A would then be an adjoining extreme, and B C, being separated from A C by the angle C, would be an opposite extreme. Neither can the angle A be the middle part; for A C would be an adjoining extreme, and B C, being separated from the angle A by the side A B, would be an opposite extreme; B C is therefore the middle part; and A C and the angle A are the opposite extremes.



But, in forming the equations, the complements of ∠ A and A C are used.

Hence from Equation 2, we have

$$\text{rad} \cdot \sin BC = \sin A \cdot \sin AC,$$

and this equation, resolved into a proportion, gives

$$\text{rad} : \sin AC :: \sin A : \sin BC.$$

To find A B.

Here ∠ A is the middle part, and A C and A B are adjoining extremes; but as in forming the equations the complements of ∠ A and A C are used, we have from the first equation

$$\text{rad} \cdot \cos A = \tan AB \cdot \cot AC,$$

and consequently $\cot AC : \text{rad} :: \cos A : \tan AB$.

To find the angle C.

Here A C is the middle part, and the angles A and C being adjacent to A C, are adjoining extremes with respect to it. But in forming the equation, the complements of all the three parts here concerned are used. Hence Equation 1 gives

$$\text{rad} \cdot \cos AC = \cot A \cdot \cot C,$$

and the equation being resolved into a proportion we have

$$\cot A : \text{rad} :: \cos AC : \cot C.$$

To determine whether the different parts of right-angled spherical triangles are obtuse or acute, we have the following rules.

1. The sides about the right angle are of the same affection with their opposite angles, and the oblique angles are of the same affection with their opposite sides.

2. When the sides about the right angle are of the same affection, the hypothenuse is acute; but when the sides about the right angle are of different affections, the hypothenuse is obtuse.

3. And hence also when the oblique angles are of the same affection,

the hypothenuse is acute; but when they are of different affections, the hypothenuse is obtuse.

As an example of the application of these rules, let us suppose that, in the last figure, A C and the angle A are both given obtuse. Then B C, being of the same affection as the angle A, is also obtuse; and as A C is obtuse, the sides A B and B C are of different affections; consequently as B C is obtuse, A B is acute; and hence its opposite angle C is acute also.

Example I.

In the right-angled spherical triangle A B C (*see the last figure*) given A B 46° 18′ 23″, and the angle A 34° 27′ 39″, to find the other parts?

Here, as the angle A is acute, B C is acute; and as A B is acute, A B and B C are of the same affection, therefore A B is also acute, and consequently the angle C is acute.

To compute A C.

In this case the angle A is the middle part, and A C and A B are adjoining extremes; hence the equation is rad . cos A = tan . A B . cot A C; and the resulting proportion to find A C is tan A B : rad :: cos A : cot A C.

Or tan A B	46° 18′ 23″	10·019811
: rad	.....	10·000000
:: cos A	34 27 39	9·916198
: cot A C	51 46 15	9·896387

To compute B C.

Here A B is the middle part, and angle A and B C are adjoining extremes, hence the equation is rad . sin A B = tan B C . cot A, and the proportion to find B C is cot A : rad :: sin A B : tan B C.

Or cot A	34° 27′ 39″	10·163503
: rad	.....	10·000000
:: sin A B	46 18 23	9·859165
: tan B C	26 23 27	9·695662

To compute ∠ C.

Here angle C is the middle part, and ∠ A and A B are opposite extremes; hence the equation is rad . cos C = cos A B . sin A, and the proportion to find ∠ C is rad : sin A :: cos A B : cos C.

Or rad	.....	10·000000
: sin A	34° 27′ 39″.	9·752695
:: cos A B	46 18 23	9·839354
: cos C	66 59 26	9·592049

Example II.

In the right-angled spherical triangle A B C (*see the last figure*) given A B 29° 41′ 32″, and B C 116° 30′ 43″, to find the other parts?

Here as A B and B C are of different affections, A C is obtuse; and the angle C, being of the same affection with A B, is acute; and the angle A, being of the same affection with B C, is obtuse.

To compute A C.

In this case A C is the middle part, and A B and B C are opposite extremes; the equation therefore is rad . cos A C = cos A B . cos B C, and the proportion to find A C is rad : cos A B :: cos B C : cos A C.

Or rad	10·000000
: cos A B 29° 41′ 32″ ..	9·938870
:: cos B C 116 30 43	9·649708
: cos A C 112 48 58	9·588578

To compute ∠ A.

Here A B is the middle part, and B C and angle A are adjoining extremes; hence the equation is rad . sin A B = tan B C . cot A, and the proportion to find ∠ A is tan B C : rad :: sin A B : cot A.

Or tan BC 116° 30′ 43″	10·302038
: rad	10.000000
:: sin A B 29 41 32	9·694904
: cot A 103 52 47	9·392866

To compute ∠ C.

Here B C is the middle part, and A B and ∠ C are adjoining extremes: hence the equation is rad . sin B C = tan A B . cot C, and the proportion to find ∠ C is tan A B : rad :: sin B C : cot C.

Or tan A B 29° 41′ 32″	9·756034
: rad	10·000000
:: sin B C 116 30 43	9·951746
: cot C 32 30 22	10·195712

Examples for Exercise.

1. In the right-angled spherical triangle A B C, given A B 118° 21′ 4″, and ∠ A 23° 40′ 12″, to find the other parts?

Answer, A C 116° 17′ 55″, ∠ C 100° 59′ 26″, and B C 21° 5′ 42″.

2. In the right-angled spherical triangle A B C, given A B 53° 14′ 20″, and ∠ A 91° 25′ 53″, to find the other parts?

Answer, A C 91° 4′ 9″, ∠ C 53° 15′ 8″, and B C 91° 47′ 11″.

3. In the right-angled spherical triangle A B C, given A B 48° 24′ 16″, and B C 59° 38′ 27″, to find the other parts?

Answer, A C 70° 23′ 42″, ∠ A 66° 20′ 40″, and ∠ C 52° 32′ 55″.

4. In the right-angled spherical triangle A B C, given A B 151° 23′ 9″, and B C 16° 35′ 14″, to find the other parts?

Answer, A C 147° 16′ 51″, ∠ C 117° 37′ 21″, and ∠ A 31° 52′ 50″.

5. In the right-angled spherical triangle A B C, given A B 73° 4′ 31″, and A C 86° 12′ 15″, to find the other parts?

Answer, B C 76° 51′ 20″ ∠ A 77° 24′ 23″, and ∠ C 73° 29′ 40″.

6. In the right-angled spherical triangle A B C, given A C. 118° 32′ 12″, and A B 47° 26′ 35″, to find the other parts?

Answer, B C 134° 56′ 20″, ∠ A 126° 19′ 2″, and ∠ C 56° 58′ 44″.

7. In the right-angled spherical triangle A B C, given A B 138° 25′ 34″, and A C 49° 27′ 16″, to find the other parts?

Answer, B C 150° 20′ 8″, ∠ A 139° 21′ 36″, and ∠ C 119° 9′ 34″.

8. In the right-angled spherical triangle A B C, given A C 68° 14′ 20″, and ∠ C 70° 21′ 15″, to find the other parts?

Answer, B C 40° 6′ 19″, A B 61° 0′ 22″, and ∠ A 43° 55′ 2″.

9. In the right-angled spherical triangle A B C, given A C 53° 25′ 31″, and ∠ A 124° 26′ 7″, to find the other parts?

Answer, B C 138° 31′ 13″, A B 142° 41′ 19″, and ∠ C 130° 59′ 38″.

10. In the right-angled spherical triangle A B C, given A C 102° 15′ 27″, and B C 49° 13′ 18″, to find the other parts?

Answer, A B 108° 58′ 9″, ∠ A 50° 47′ 47″, and ∠ C 104° 35′ 21″

11. In the right-angled spherical triangle A B C, given ∠ C. 38° 14′ 3″, and ∠ A 59° 20′ 7″, to find the other parts?

Answer, B C 34° 30′ 11″, A B 24° 3′ 2″, and A C 41° 11′ 17″.

12. In the right-angled spherical triangle A B C, given ∠ C 171° 4′ and ∠ A 92° 6′, to find the other parts?

Answer, A C 76° 30′ 37″, A B 171° 18′ 56″, and B C 103° 38′ 57″.

13. In the right-angled spherical triangle A B C, given A C 61° 3′ 22″, and ∠ A 49° 28′ 12″, to find the other parts?

Answer, A B 49° 36′ 6″, ∠ C 60° 29′ 19″, and B C 41° 41′ 32″.

14. In the right-angled spherical triangle A B C, given A B 29° 12′ 50″, and ∠ C 37° 26′ 21″, to find the other parts?

Answer, ambiguous, ∠ A 65° 27′ 58″ or its supplement, A C 53° 24′ 13″ or its supplement, B C 46° 55′ 2″ or its supplement.

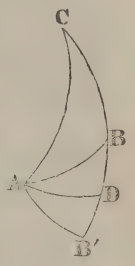
15. In the right-angled spherical triangle A B C, given A B 54° 21′ 35″, and ∠ C 61° 2′ 15″, to find the other parts?

Answer, ambiguous, B C 129° 28′ 28″ or its supplement, A C 111° 44′ 34″ or its supplement, and ∠ A 123° 47′ 44″ or its supplement.

APPLICATION OF THE FORMULÆ FOR RIGHT-ANGLED SPHERICAL TRIANGLES TO THE SOLUTION OF CASES RELATIVE TO QUADRANTAL TRIANGLES.

A quadrantal triangle is a spherical triangle, one of whose sides is a quadrant.

Let A B C or A B′ C be a quadrantal triangle, A C being the quadrantal side, on C B′ or C B produced, let C D be taken equal to a quadrant, and let A D be an arc of a great circle passing through A and D. Then the angles C A D, C D A (or B D A) and B′ D A are right angles, and A D is the measure of the angle C. The angles D A B, D A B′, are respectively complements of C A B, C A B′; and C B, C B′ are also respectively complements of B D, B′ D. Hence the different parts of the quadrantal triangles B′ A C, B A C, may be determined from the corresponding parts of the right-angled triangles A D B, A D B′.



Example I.

In the triangle A B′ C, given A C 90°, the angle C A B′ 112° 2′ 9″, and A B′ 67° 3′ 14″, to find the other parts?

Let C D be a quadrant, then as C A D is a right angle, D A B′ is 22° 2′ 9″. Hence D B′ is acute; and as A B′ is acute, the angle B′ and A D, the measure of the angle C, are also acute.

To compute A D, *or the measure of* ∠ C.

Equation, rad . cos D A B′ = cot A B′ . tan A D.

Or cot A B′	67° 3′ 14″	9·626715
: rad	.....	10·000000
:: cos D A B′	22 2 9	9·967057
: tan A D	65 27 9	10.340342

To compute D B′, *the complement of* B′ C.

Equation, rad . sin D B′ = sin D A B′ . sin A B′.

Or rad	.....	10·000000
: sin D A B′	22° 2′ 9″	9·574246
:: sin A B′	67 3 14	9·964199
: sin D B′	20 12 44	9·538445
	90	
B′C	110 12 44	

To find the angle B′.

Equation, rad . cos A B′ = cot D A B′ . cot ∠ B′.

Or cot D A B′	22°	2′	9″	10·392809
: rad				10·000000
:: cos A B′	67	3	14	9·590915
: cot ∠ B′	81	1	58	9·198106

EXAMPLE II.

In the triangle A B′ C, given A C 90°, A B′ 79° 18′ 40″, and C B′ 123° 16′ 3″, to find the other parts?

Let C D be a quadrant, then D B′, the complement of C B′, is 33° 16′ 3″.

To find the angle B′.

Equation, rad . cos ∠ B′ = cot A B′ tan D B′.

Or rad				10·000000
: cot A B′	79°	18′	40″	9·275889
:: tan D B′	33	16	3	9·816946
: cos ∠ B′	82	53	12	9·092835

To find A D, *or the measure of the angle* C.

Equation, rad . cos A B′ = cos D B′ . cos D A.

Or cos D B′	33°	16′	3″	9·922268
: rad				10·000000
:: cos A B′	79	18	40	9·268288
: cos A D	77	11	0	9·346020

To find the angle D A B′.

Equation, rad . sin D B′ = sin A B′ . sin D A B′.

Or sin A B′	79°	18′	40″	9·992398
: rad				10·000000
:: sin D B′	33	16	3	9·739216
: sin D A B′	33	56	2	9·746818

	90		
C A B′	123	56	2

EXAMPLES FOR EXERCISE IN THE SOLUTION OF QUADRANTAL TRIANGLES.

1. In the quadrantal triangle A B C (*see the last figure*) A C being the quadrantal side, given A B 67° 3′ and ∠ A 49° 18′, to find the other parts?

Answer, ∠ C 60° 48′ 54″, B C 53° 5′ 46″, and ∠ B 108° 32′ 27″.

2. Given $\angle$ A 118° 40′ 36″, and B′C 113° 2′ 28″, to find the other parts?

Answer, A B′ 54° 38′ 57″, $\angle$ C 51° 2′ 35″, and $\angle$ B′ 72° 26′ 21″.

3. Given $\angle$ C 69° 13′ 46″, $\angle$ A 72° 12′ 4″, to find the other parts?

Answer, A B 70° 8′ 39″, B C 73° 17′ 29″, and $\angle$ B 96° 13′ 23″.

4. Given B C 86° 14′ 40″, and $\angle$ A 37° 12′ 20″, to find the other parts?

Answer, A B 4° 43′ 2″, $\angle$ B 142° 42′ 2″, and $\angle$ C 2° 51′ 23″.

5. Given $\angle$ C 60° 41′ 30″, and B C 78° 12′ 19″, to find the other parts?

Answer, A B 61° 22′ 7″, $\angle$ A 76° 31′ 59″, and $\angle$ B 96° 32′ 45″.

6. Given B′ C 118° 32′ 16″, and A B′ 67° 48′ 40″, to find the other parts?

Answer, $\angle$ C 64° 32′ 21″, $\angle$ A 121° 3′ 46″, and $\angle$ B′ 77° 11′ 6″.

7. Given B C 58° 3′ 42″, and A B 61° 4′ 19″, to find the other parts?

Answer, $\angle$ C 55° 15′ 0″, $\angle$ B 110° 9′ 10″, and $\angle$ A 52° 48′ 46″.

8. Given $\angle$ B 104° 41′ 17″, and B C 73° 21′ 6″, to find the other parts?

Answer, $\angle$ A 67° 56′ 13″, $\angle$ C 47° 32′ 39″, and A B 49° 42′ 18″.

9. Given $\angle$ A 21° 39′ 48″, and $\angle$ C 53° 26′ 45″, to find the other parts?

Answer, $\angle$ B 123° 36′ 32″, B C 26° 18′ 40″, and A B 74° 41′ 35″.

10. Given $\angle$ B 94° 29′ 54″, and B C 56° 31′ 26″, to find the other parts?

Answer, $\angle$ A 56° 15′ 29″, $\angle$ C 81° 53′ 0″, and A B 83° 14′ 11″.

APPLICATION OF TRIGONOMETRICAL FORMULÆ TO THE NUMERICAL COMPUTATION OF THE DIFFERENT PARTS OF OBLIQUE-ANGLED SPHERICAL TRIANGLES.

All the cases of oblique-angled spherical triangles may be solved by the formulæ for right-angled ones, except when the three sides are given to find the angles, or the three angles given to find the sides. For the solution of these two cases, we have the following rules.

To find any angle of a spherical triangle when the three sides are given.

Rule 1. From half the sum of the three sides subtract the side opposite to the required angle, then add together the log cosecants of the other two sides (rejecting 10 from each of their indexes), and the log sines of the half sum, and remainder; half the sum of these four logarithms will be the log cosine of half the required angle.

Rule 2. From half the sum of the three sides, subtract each of the sides containing the required angle, then add together the log cosecants of these two sides (rejecting 10 from each of their indexes) and the log sines of the two remainders; half the sum of these four logarithms will be the log sine of half the required angle.

Remark. When the required angle is large, the first of these rules may be used in preference, and the second when the angle is small.

When the three angles are given to find the sides.

Rule. Take the supplements of the measures of the given angles, as the sides of another triangle, and find the angles of that triangle by either of the preceding rules; and the supplement of the measures of these angles will be the sides of the proposed triangle, the greater side being opposite the greater angle.

When a side and two of the angles, or an angle and two of the sides, are given to find the other parts.

Rule. Let a perpendicular be drawn from an extremity of a given side, and opposite a given angle, or its supplement; there will then be formed two right-angled triangles, the parts of which may be computed by Napier's Rules.

The following proportions however, which were deduced at Prop. 16 and 17, Elements of Spherics, will often be found useful.

1. *The sines of the sides of spherical triangles are proportional to the sines of their opposite angles.*

2. *The sines of the segments of the base, made by a perpendicular from the opposite angle, are proportional to the cotangents of their adjacent angles.*

3. *The cosines of the segments of the base are proportional to the cosines of the adjacent sides of the triangle.*

4. *The tangents of the segments of the base are proportional to the tangents of the opposite segments of the vertical angles.*

5. *The cosines of the angles at the base are proportional to the sines of the corresponding segments of the vertical angles.*

6. *The cosines of the segments of the vertical angles are proportional to the cotangents of the adjoining sides of the triangle.*

When two sides and the included angle are given, the other angles may be conveniently found from the following rule.

Add together the cotangent of half the given angle, the secant of half the sum of the given sides, and the cosine of half their difference, and the sum, rejecting 20 from the index, is the tangent or half the sum of the required angles. Again, add together the cotangent of half the given angle, the cosecant of half the sum of the given sides, and the sine of half their difference, and the sum, rejecting 20 from the index, is the tangent of half the difference of the required angles. And half

the difference added to half the sum gives the greater, and subtracted, leaves the less of the required angles. (*Prop.* 21, *Spherics.*)

When two angles and an adjacent side are given to find the other sides, the following rule may be employed with advantage.

Add together the tangent of half the given side, the secant of half the sum of the given angles, and the cosine of half their difference, and the sum, rejecting 20 from the index, is the tangent of half the sum of the required sides. Again, add together the tangent of half the given side, the cosecant of half the sum of the given angles, and the sine of half their difference, and the sum, rejecting 20 from the index, is the tangent of half the difference of the required sides. Then, knowing the half sum and the half difference, the sides themselves are known, the greater side being opposite the greater angle. (*Prop.* 21, *Spherics.*)

Note. Half the sum of the sides is of the same affection as half the sum of the opposite angles; and half the difference of the sides, as well as half the difference of the angles, is always acute.

When two sides and the contained angle are given to find the third side, by direct computation.

Add together the sines of the two sides, and twice the cosine of half their included angle, and half the sum, rejecting tens from the index, will be the sine of an arc. Add together the sines of the sum and the difference of that arc, and half the sum of the given sides, and half the sum of the logarithms, will be the sine of half the required side. (*Prop.* 22, *Spherics.*)

EXAMPLES.

1. In the triangle A B C, given A B 59° 16′ 23″, B C 70° 4′ 18″, and A C 63° 21′ 27″, to find the other parts?

∠ A *found by the first Rule.*

B C	70°	4′	18″		
A B	59	16	23	cosec	·065697
A C	63	21	27	cosec	·048749
	2)192	42	8		
	96	21	4	sin	9·997326
	26	16	46	sin	9·646158
					2)19·757930
	40	49	10	cos	9·878965
			2		
	81	38	20	∠ A	

∠ B *found by the second Rule.*

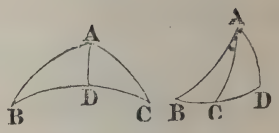
A C	63°	21′	27′		
A B	59	16	23	cosec	·065697
B C	70	4	18	cosec	·026817
	2)192	42	8		
	96	21	4		
	37	4	41	sin	9·780247
	26	16	46	sin	9·646158
					2)19·518919
	35	4	49	sin	9·759459
			2		
	70	9	38	∠ B	

∠ C *found by the first Rule.*

A B	59°	16′	23″		
B C	70	4	18	cosec	·026817
A C	63	21	27	cosec	·048749
2)	192	42	8		
	96	21	4	sin	9·997326
	37	4	41	sin	9·780247
				2)	19·853139
	32	23	17	cos	9·926569
			2		
	64	46	34	∠ C	

2. In the triangle A B C, given B C 91° 3′ 26″, A B 40° 36′ 37″, and ∠ B 58° 31′, to find the other parts?

Let A D (see the first of the adjoining figures) be a circle drawn through C, perpendicular from A upon B C. Then in the right-angled triangle B A D are given A B and ∠ B to find the other parts. Now as A B and ∠ B are both given acute, B D, D A, and ∠ B A D are all acute.



To find B D.

Radius . cos ∠ B = tan B D . cot A B.

Or cot A B	40°	36′	37″	....	10·066810
: rad				.....	10·000000
:: cos ∠ B	58	31	0	....	9·717879
: tan B D	24	7	19	....	9·651069
B C	91	3	26		
D C	66	56	7		

To find ∠ B A D.

Radius . cos A B = cot ∠ B . cot B A D.

Or cot ∠ B	58°	31′	0″	..	9·787036
: rad				.....	10·000000
:: cos A B	40	36	37	..	9·880330
: cot ∠ B A D	38	53	34	..	10·093294

As A D and D C are both acute, A C and the angles A C D, D A C, are also acute.

To find A C.

As cos B D	24° 7′ 19″ ..	9·960317
: cos D C	66 56 7 ...	9·593032
:: cos A B	40 36 37 ...	9·880330
		19·473362
: cos A C	70 58 54 ...	9·513045

To find ∠ C A D.

As tan B D	24° 7′ 19″ ..	9·651066
: tan D C	66 56 7 ..	10·370786
:: tan B A D	38 53 34 ...	9·906706
		20·277492
: tan C A D	76 42 6 ...	10·626426

115 35 40 B A C or sum of B A D and C A D.

To find ∠ C.

As sin B D	24° 7′ 19″ ..	9·611383
: sin D C	66 56 7 ...	9·963817
:: cot ∠ B	58 31 0 ...	9·787036
		19·750853
: cot ∠ C	35 57 15 ...	10·139470

To find the angles A *and* C *by the first Rule, page* 131.

B C	91° 3′ 26″
B A	40 36 37
Sum	131 40 3
Diff.	50 26 49
Half sum	65 50 1·5
Half diff.	25 13 24·5
Half ∠ B	29 15 30

To compute $\frac{A+C}{2}$ *and* $\frac{A-C}{2}$.

	29° 15′ 30″	cot	10·251643	cot	10·251643
	65 50 1·5	sec	10·387867	cosec	10·039833
	25 13 24·5	cos	9·956482	sin	9·629562
$\frac{A+C}{2}$	75 46 27·2	tan	10·595992		
$\frac{A-C}{2}$	39 49 11·5			tan	9·921038
Sum	115 35 38·7 ∠ A				
Diff.	35 57 15·7 ∠ C.				

A C *found directly by the second Rule, page* 131.

$\frac{B}{2}$	29° 15′ 30″	2 cos		19·881456
B C	91 3 26	sin		9·999926
A B	40 36 37	sin		9·813521
Sum	131 40 3		2)	19·694903
Half sum	65 50 1			
	44 43 58	sin		9·847452
Sum	110 33 59	sin		9·971399
Diff.	21 6 3	sin		9·556315
			2)	19·527714
	35 29 27	sin		9·763857
	2			
A C	70 58 54			

Examples for Exercise.

1. In any triangle A B C, given A C 118° 2′ 14″, ∠ A 27° 22′ 34″, and A B 120° 18′ 33″, to find the other parts?

Answer, B C 23° 57′ 13″, ∠ B 91° 26′ 44″, and ∠ C 102° 5′ 54″.

2. Given ∠ A 81° 38′ 17″, ∠ B 70° 9′ 38″, and ∠ C 64° 46′ 32″, to find the sides?

Answer, A B 59° 16′ 23″, B C 70° 4′ 18″, and ∠ C 63° 21′ 27″.

3. Given A B 64° 26′, ∠ A 49°, and ∠ B 52°, to find the other parts?

Answer, A C 45° 56′ 46″, B C 43° 29′ 49″, and ∠ C 98° 28′ 5″.

4. Given A B 96° 14′ 50″, B C 93° 27′ 34″, and A C 100° 4′ 26″, to find the angles?

Answer, ∠ A 94° 39′ 4″, ∠ B 100° 32′ 19″, and ∠ C 96° 58′ 36″.

5. Given A B 67° 14′ 28″, B C 40° 18′ 29″, and ∠ A 34° 22′ 17″, to find the other parts?

Answer, ambiguous, A C being 89° 47′ 6″, ∠ C 53° 35′ 16″, and ∠ B 119° 13′ 31″; or A C 36° 19′ 48″, ∠ C 126° 24′ 44″, and ∠ B 31° 7′ 59″.

6. Given A B 81° 26′ 37″, ∠ A 40° 18′ 22″, and ∠ B 67° 3′ 29″, to find the other parts?

Answer, B C 40° 50′ 55″, ∠ C 102° 2′ 36″, and A C 68° 36′ 48″.

7. Given A B 128° 13′ 47″, ∠ C 131° 11′ 12″, and B C 77° 25′ 11″, to find the other parts?

Answer, A C 84° 29′ 24″, ∠ A 69° 14′, and ∠ B 72° 28′ 46″.

8. Given A C 97° 18′ 39″, A B 86° 53′ 46″, and B C 89° 21′ 37″, to find the other parts?

Answer, ∠ A 88° 57′ 20″, ∠ B 97° 21′ 26″, and ∠ C 86° 47′ 17″.

9. Given B C 74° 16′, ∠ B 46° 34′, and ∠ C 81° 20′, to find the other parts?

Answer, A C 44° 34′ 42″, ∠ A 84° 46′ 35″, and A B 72° 50′ 43″.

10. Given ∠C 77° 22′ 21″, ∠A 71° 33′ 30″, and ∠ B 57° 53′ 55″, to find the sides?

Answer, A B 61° 14′, B C 58° 27′, and A C 49° 33′.

11. Given A B 80° 12′ 21″, B C 50° 36′ 39″, and ∠ B 68° 40′ 26″, to find the other parts?

Answer, A C 67° 21′ 40″, ∠A 51° 15′ 50″, and ∠C 95° 58′ 1″.

12. Given A C 100° 21′ 30″, B C 97° 18′ 22″, and ∠ B 100° 28′ 48″, to find the other parts?

Answer, A B 19° 22′ 2″, ∠ C 19° 21′ 33″, and ∠ A 82° 31′ 14″.

13. Given ∠ A 59° 29′ 6″, ∠ B 54° 39′ 32″, and A B 68° 32′ 46″, to find the other parts?

Answer, ∠C 92° 6′ 11″, A C 49° 26′ 18″, and B C 53° 21′ 17″.

14. The perpendicular C D falling within the triangle, given A D 6° 25′ 33″, B D 42° 54′ 46″, and ∠ A 82° 33′ 53″, to find the other angles and the sides?

Answer, ∠ B 51° 33′ 4″, B C 56° 13′ 24″, and A C 41° 2′ 0″.

15. The perpendicular C D falling without the triangle, given A D 27° 36′ 3″, B D 79° 49′ 3″, and C D 15° 40′ 21″, to find the sides and angles of the triangle A B C?

Answer, ∠ A 148° 48′ 6″, ∠ B 15° 54′ 38″, ∠C 24° 32′ 52″, A B 52° 13′, B C 80° 12′, and A C 31° 26′.

16. Given A B 110°, B C 116°, and A C 116°, to find the angles?

Answer, ∠ A 134° 9′ 5″, ∠ B 134° 9′ 5″, and ∠ C 131° 23′ 48″.

17. Given A B 53° 16′ 32″, B C 48° 26′ 39″, and A C 51° 36′ 30″, to find the angles?

Answer, ∠A 62° 18′ 11″, ∠B 68° 1′ 55″, and ∠C 71° 30′ 37″.

18. Given A B 86° 12′ 52″, B C 79° 38′ 21″, and A C 58° 39′ 16″, to find the angles?

Answer, ∠ A 80° 10′ 10″, ∠ B 58° 48′ 36″, and ∠ C 91° 52′ 42″.

ELEMENTARY PRINCIPLES

OF

NAVIGATION.

NAVIGATION is the art of conducting a ship from one place to another.

That this art may be rightly understood, or practised with advantage, it is necessary that the navigator should be acquainted with the form of the earth, the relative situation of the lines conceived to be drawn upon its surface, and be furnished with correct charts of such parts of it as he may have occasion to visit, as well as with tables, in which the situations of the most remarkable sea coasts, islands, rocks, shoals, &c. are accurately described: and he must also understand the use and application of such instruments as are necessary to determine the direction in which the ship is steered, and the distance which she sails; and be further possessed of sufficient mathematical skill to deduce, from the data which these instruments furnish, the situation of the ship at any time; and to find the direction and distance of any place to which it may be required that the ship should be taken.

That the earth, in its general figure, is a round body is evident from various considerations. If it were flat, then in clear weather, though distant objects upon its surface might appear small, they would still be within the limit of view; but it is uniformly observed, in every part of the earth, that to whatever quarter a ship sails, after she has proceeded a few miles to sea, she is gradually lost sight of, appearing as it were to sink in the waters, or to be hidden behind their convexity; the lower parts disappearing first, and the higher in succession. Now the figure of the object on which this appearance uniformly takes place must necessarily be round.

In lunar eclipses, which are caused by the moon's passing through the shadow of the earth, it is always observed that the bounding line of the shadow on the face of the moon is a curve line; the earth therefore, which casts that shadow, must be a round body. To these and many other considerations it may be added, that several celebrated navigators, by proceeding forward always, or as nearly as circumstances admitted, in the same direction, have actually arrived at the place which they sailed from, and have thus sailed round, or circumnavigated the earth.

But though the figure of the earth is *nearly* spherical, it is not *exactly* so. It revolves round one of its diameters once in a day; and this revolution produces an effect upon its figure, which, in nice observations, becomes very apparent. *It is flattened towards the extremities*

of the axis of rotation, but so slightly, that in computing the place of a ship, from the distance which she has gone, and the direction in which she has sailed, the earth may be safely considered as a sphere.

The diameter round which it revolves is called the *axis*, and the extremities of that diameter the *poles* of the earth. That to which we in Europe are nearest is called the *north pole*, and the other the *south pole*.

Great circles passing through the poles are called *meridians;* the great circle, equidistant from both poles, and which therefore cuts the meridians at right angles, is called the *equator*, the *equinoctial*, or the *line;* and less circles, whose planes are parallel to the plane of the equator, are called *parallels of latitude*. The meridian passing over any place is called the meridian of that place; and the portion of a meridian intercepted between a place and the equator is called the *latitude* of that place; and it receives the denomination of *north* or *south*, according as the place is on the north or south side of the equator.

It is customary to call the meridian of some remarkable place the first meridian, and the angle included between the first and any other meridian is called the *longitude* of that other meridian, or of any place over which the meridian passes. And as the angle included between two great circles is measured by the arc which they intercept on another great circle, whose pole is at the point of their intersection, the *longitude of a place* may also be defined to be *the arc of the equator intercepted between the first meridian and the meridian of that place;* and it is considered as *east* or *west*, according as the place is situated towards the east or west of the first meridian. English geographers and seamen refer to the meridian of the Royal Observatory at Greenwich as the first meridian, Frenchmen to that of the Observatory at Paris, &c.

The *difference of latitude* between any two places is an arc of a meridian intercepted between the parallels of latitude on which the places are situated; and the *difference of their longitudes* is the angle at the pole included between their meridians, or the arc of the equator which those meridians intercept.

Hence when the latitudes or the longitudes of two places are of the *same* denomination, the difference of their latitudes, or of their longitudes, will be found by subtracting the less from the greater; but when they are of *different* denominations, by taking their sum.

A curve that cuts every meridian which it meets at the same angle, is called a *rhumb line;* the angle which the rhumb line makes with the meridian is called the *course* between any two places through which the rhumb passes; and the arc of a rhumb line intercepted between two places is called their *nautical distance*.

The *meridian distance* which a ship has made is an arc of the parallel on which the ship is, intercepted between the meridian left

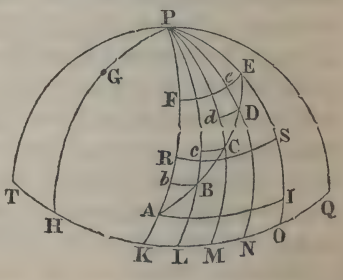
and the meridian arrived at; and the *departure* which a ship makes in sailing upon a rhumb line, *is the sum of all the intermediate meridian distances, computed on the supposition that the distance is divided into indefinitely small equal parts.*

The parallel of latitude, which is 23° 28′ north of the equator, is called the *tropic of cancer;* and that which is 23° 28′ south of the equator is called the *tropic of capricorn.* The parallel of latitude, which is 23° 28′ from the north pole, is called the *arctic circle;* and that which is at the same distance from the south pole, is called the *antarctic circle.* These four circles divide the surface of the earth into five parts, called *zones.* The part included between the tropics is called the *torrid* or *burning zone*, from the intense heat produced by the vertical action of the sun's rays. Those included between the poles and the arctic and antarctic circles, are called *frigid* or *frozen zones,* from the great cold arising from the periodical absence of the sun, and the obliquity with which his rays at all times meet the surface of those parts of the earth. The two remaining parts are called *temperate zones*, from their enjoying the advantages of an intermediate state, between the extremes of heat and cold which prevail in the torrid and frigid zones.

The equator bisects the torrid zone, and also divides the whole surface of the earth into two equal parts; that in which the north pole is situated being called the northern hemisphere, and the other the southern hemisphere.

With respect to the magnitude of the earth, it has been found, by various admeasurements, that it is nearly equal to a sphere of 7916 English miles in diameter, or 24869 miles in circumference. Hence, a geographical or a nautical mile, which is the 21600th of 360°, is nearly 6079 English feet.

For the sake of illustration, let us suppose that in the annexed figure, P is the north pole, T K Q the equator, or a great circle, every part of which is a quadrant distant from P; P T, P H, P K, &c. great circles passing through P, and of course cutting the equator at right angles; A I, *b* B, R S, &c. arcs of smaller circles parallel to the equator, and therefore cutting the meridians at right angles; A E a curve cutting every meridian which it meets, as P K, P L, P M, &c. at the same angle. Then P H, P K, &c. produced till they meet at the opposite pole, are called meridians; A I, *b* B, R S, &c. continued round the globe, are called parallels of latitude; A E is called the rhumb line, passing through A and E; the length of A E is called the nautical



distance from A to E; and the angle *b* A B, or any of its equals, *c* B C, *d* C D, &c. is called the course from A to E. Let G be the situation of Greenwich, then G H is the latitude of Greenwich, G P its colatitude, A K the latitude of the point A, or of any place on the parallel A I; F K, or its equal E O, is the latitude of F, or of E, or of any place on the parallel F E; F A or E I is the difference of latitude of the points A and E, or of the parallels A I and E F, or of any places on those parallels.

As P G H is the first meridian, the longitude of G, or of any place on the meridian P G H, is nothing; the arc T H, or the angle T P H, which T H measures, is the longitude of the meridian P T, or of any place on that meridian; the arc H K, or the angle H P K, is the longitude of A, or of F, or of any place on the meridian P K; the arc H O, or the angle H P O, is the longitude of the points O, I, S, and E, or of any place on the meridian P O; the arc K O, which is the difference of H O and H K, is the difference of the longitudes of the meridians P K and P O, or of any two places on those meridians; and T O, the sum of T H and H O, is the difference of longitude of the meridians P T and P O.

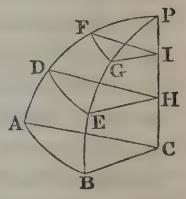
If a ship sail from A to E, E F is her meridian distance; but if she sail from E to A, A I is her meridian distance.

If A B, B C, C D, &c. be conceived to be equal, and indefinitely small, and their number indefinitely great, then the triangles A B *b*, B C *c*, &c. may be considered as indefinitely small right-angled plane triangles. And as the angles B A *b*, C B *c*, &c. are equal, and the right angles A *b* B, B *c* C, &c. are equal, the remaining angles A B *b*, B C *c*, &c. are equal; and as the sides A B, B C, &c. are also equal, these elementary triangles A B *b*, B C *c*, C D *d*, &c. are all identical triangles; therefore A E is the same multiple of A B, that the sum of A *b*, B *c*, C *d*, &c. is of A *b*; and that the sum of B *b*, C *c*, D *d*, &c. is of B *b*. But the sum of A *b*, B *c*, C *d*, &c. is equal to the whole difference of latitude A F, or E I, and the sum of B *b*, C *c*, D *d*, &c. is what is called the *departure*. Hence as A B *b* is a right-angled plane triangle, a straight line equal to A E, and a straight line equal to A F, will form two sides of a right-angled plane triangle, of which the third side will be equal to the sum B *b*, C *c*, D *d*, &c., and the angle included by the lines equal to A E and A F will be equal to the angle B A *b*, made by the rhumb line with the meridian on the globe.

Therefore, when any two of these four elements are given, viz. the *difference of latitude*, *course*, *nautical distance*, and *departure*, the other two may be found by the resolution of a right-angled plane triangle; of which the hypothenuse is the distance, the side opposite the course the departure, and the remaining side the difference of latitude.

It may be observed here, that when the rhumb line on which a ship sails coincides with a meridian, *the difference of latitude is the nautical distance*, and the ship changes her *latitude only*, not her longitude; and when the rhumb line cuts the meridians at right angles, the *nautical distance is equal to the meridian distance*, and the ship changes her *longitude only*, and not her latitude; but in *every other direction of the rhumb line*, *both the latitude and longitude will be changed*. We have seen, however, that computations made on the supposition that the earth is a plane, the meridians parallel straight lines, and the rhumb lines in consequence also straight lines, give correct results, so far as difference of latitude, course, departure, and nautical distance are concerned. This is called PLANE SAILING, and its usefulness is hence very obvious. But we have now to consider how the *longitude* of a ship may be computed when she sails a given distance from a known place and on a given rhumb line: or generally to shew how *a ship's change of longitude is connected with her change of place on the globe*.

We shall begin with the most simple case of the general problem, viz. that in which a ship sails on a parallel of latitude, or when she changes her longitude only. Let P A and P B be two meridians, A B the arc of the equator which they intercept, or the difference of their longitudes; let the planes of the meridians intersect each other in P C (C being the centre of the globe,) and let A C B be the plane of the equator, and D H E, F I G, the planes of any two parallels of latitude, of which the parts corresponding to the difference of longitude A B, are D E and F G respectively. Then as D H and H E are respectively parallel to A C and B C (for each of these lines is perpendicular to P C), the angle D H E is equal to the angle A C B, and consequently the arc D E is the same portion of the whole parallel of which it is a part, that the arc A B is of the equator.



Hence D E is to A B, as D H, the radius of the parallel, is to A C, the radius of the equator, or the radius of the globe. But D H is the sine of D P, or cosine of D A, the latitude of the parallel; therefore, as the cosine of any given latitude is to any portion of a parallel in that latitude, so is radius to the corresponding arc of the equator, or the difference of longitude.

But in any right-angled plane triangle, the base is to the hypothenuse as the cosine of the acute angle at the base is to radius; therefore if the angle at the base of a right-angled plane triangle be measured by any given latitude, and the length of the base be equal to any given portion of a parallel in that latitude, the hypothenuse will be equal to the arc of the equator, or the difference of longitude, corresponding to the given meridian distance, or the given arc of the parallel.

Again it may be shewn, in the same way, that D H is to F I as D E is to F G; or as the cosine of any latitude is to any portion of the parallel in that latitude, so is the cosine of any other latitude to the corresponding portion of its parallel. Hence if two right-angled plane triangles have a common hypothenuse, equal to the difference of longitude of any two meridians, and the angles at the base of the triangles be respectively measured by any given latitudes, their bases will represent the arcs of two parallels which correspond, in their respective latitudes, to the proposed difference of longitude.

The above are the elementary principles of what is called PARALLEL SAILING; we have next to consider how the difference of longitude may be determined, when a ship sails *upon an oblique rhumb.*

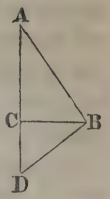
For this purpose let us recur to the figure on page 138. In that figure, the elementary and equal parts of the departure B *b*, C *c*, D *d*, &c. are severally *less* than the corresponding parts of the parallel A I, but *greater* than those of the parts which correspond to them on the parallel F E. If, however, R S be the arc of the middle parallel between F E and A I, the elementary parts of the departure on one side of R S will exceed the corresponding parts of that line, by *nearly* as much as the elementary parts of the departure on the other side of R S are *less* than the corresponding parts of that line. Hence R S, the meridian distance in the middle latitude, is *nearly* equal to the departure, or the sum of the elementary meridian distances that arise in sailing on an oblique rhumb. Therefore, considering the departure as a meridian distance on the middle parallel, between the latitude left and the latitude arrived at, the difference of longitude may be computed in the same manner as in parallel sailing.

For if the angle at the base of a right-angled plane triangle be measured by the middle latitude, and the base be equal to the departure, the hypothenuse will be *nearly* equal to the difference of longitude; not *exactly equal;* for though, in places near the equator, or indeed for such short distances as an ordinary day's run in any situation, except in very high latitudes, the meridian distance in the middle parallel may, without any important sacrifice of accuracy, be taken for the departure, they are in no case *exactly equal.*

This method of connecting the change in longitude with a ship's change of place, is called MIDDLE LATITUDE SAILING.

To exhibit more plainly the practical application of what has been here said, let D E (see the last figure), a given meridian distance, in a given latitude A D, be represented by the line A B in the annexed figure; then if the angle B A C in the annexed figure be measured by the latitude A D, in the former one, A C in this figure will be equal to A B, the difference of longitude, in the other figure.

Again, if A E (see figure, page 138) be represented by D B in this figure, and A F in that figure by D C in this, then the angle B C D will be a right angle, and B C the departure, which will be *correctly* equal to the sum of B *b*, C *c*, &c. (fig., page 138) and *nearly* equal to R S, in that figure, the meridian distance in the middle latitude. If, therefore, in the right-angled triangle B C A, the angle C B A be measured by the middle latitude, or the latitude of the parallel R S; then A B, the hypothenuse, in this figure, will be *nearly* equal to K O (figure, page 138), the difference of longitude which the ship has made in sailing from A to E. If, therefore, in these two connected right-angled triangles, D C be the difference of latitude, B D the nautical distance, and C B A the middle latitude; then C D B is the course, C B the departure, or the meridian distance in the middle latitude *nearly*, and A B the difference of longitude *nearly*.



The solution of the leading problems in navigation being thus in practice reduced to the computation of the different parts of two right-angled plane triangles, as D B C, B C A, having the meridian distance in the middle latitude for a common side, and forming together one triangle, as A B D, the different parts of those triangles may be determined from each other by trigonometry, inspection, or otherwise; but there are one or two useful relations among the parts of the triangles, to which it may be well to draw the student's particular attention.

1. In the oblique-angled triangled A B D,

$$\sin A : B D :: \sin D : A B.$$

But the angle A is the complement of the angle A B C, the middle latitude, therefore this proportion is

$$\cos . \text{ mid lat} : \text{dist} :: \sin . \text{ course} : \textit{diff long}.$$

2. In the right-angled triangles D C B and B C A. (Trig., Prop. 4)

$$D C . \tan B D C = C B . \text{rad}$$

and $$B A . \cos C B A = C B . \text{rad}$$

Therefore $$D C . \tan B D C = B A . \cos C B A$$

or $$D C : B A :: \cos C B A : \tan B D C$$

that is, diff lat: diff long :: cos mid lat : tan course.

These two proportions may be varied according to the data which may be given.

There is however another, and a very ingenious method, by which the connection between a ship's change in longitude and her change of place may be determined, called, from its inventor, Mercator's Sailing. In this method the globe is conceived to be so projected on a plane, that the meridians are parallel lines, and the elementary parts of the meridians and parallels bear, in all latitudes, the same proportion to each other that they do upon the globe.

Now, as the meridians are all great circles, and the parallels are all

small circles of the globe, it is evident that, except at the equator, no given part of a meridian can be equal to a like part of its parallel; and as the parallels diminish towards the poles, their like parts will also diminish; and, consequently, any given portion of a meridian will differ more from a like portion of a parallel, according as the parallel is at a greater distance from the equator.

But as in Mercator's projection of the globe the meridians are parallel to each other, the distance of any two meridians will in all latitudes be the same, and equal also to the difference of longitude of those meridians. Hence as the parallels are less than the equator, but in the projection they are all made equal to it, they are all in the projection increased beyond their relative magnitudes on the globe; those which are *least* in themselves, or whose latitudes are *greatest*, being increased *most*. If therefore the elementary parts of the meridians bear the same proportion to the like parts of their parallels in the projection, that they do to each other on the globe, the elementary parts of the meridian must, in the projection, be increased in the same proportion as those of the parallels are; and as the parallels distant from the equator are most increased, the elementary parts of the projected meridian must increase more and more as they are at a greater distance from the equator.

To investigate the proportion in which this increase must take place, we have already seen that, cosine latitude : radius, or radius : sect lat :: any portion of a parallel : a like portion of the equator. But the equator and meridian are equal circles, therefore radius : sect lat :: any portion of the parallel : a like portion of the meridian.

Now in Mercator's projection the parallels are all equal to the equator, or to the meridian on the globe; therefore, in this projection, radius : sect lat :: an elementary part of a meridian on the globe : the length of that elementary part in the projection. Or if we take radius equal to unity, and consider $1'$ as an elementary portion of the meridian, we have rad (1) : sect lat :: $1'$: the length of $1'$ in the projection. Hence the length of $1'$ in the projection in any latitude is equal to the natural secant of that latitude, the radius being unity.

Therefore in lat $1'$, $1'$ of lat = sec $1'$ in the projection

$2'$, = sec $2'$

$3'$, = sec $3'$ &c.

And consequently sec $1' +$ sec $2' +$ sec $3'$ is the distance of the third minute of the meridian from the equator in the projection; and this sum, which is found in Table 3, is called the meridional parts of $3'$.

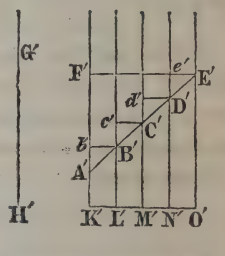
In this manner may the meridional parts corresponding to every portion of the meridian be computed; but the smaller the part is which is taken as the elementary part of the meridian, so much the more exactly will the length of the parts of it in the projection be

obtained. Instead of taking 1′ as the elementary part, we might have taken 1″, and the method of computation would have been precisely the same. The calculation of course would have been lengthened; but even in the latitude of 70° the length of the projected meridian from the equator would not have differed much more than half a minute from that by the calculation having 1′ for its base.

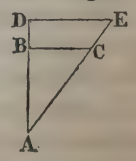
There are other methods by which the computation of the length of the projected meridian may be more expeditiously made; but the above will give the student a distinct conception of the nature of the artifice by which the proportion between the meridians and parallels is preserved, and of the principles of *one* method by which he may examine for himself the accuracy of the numbers contained in his table.

Now, as in this projection the meridians are parallel straight lines, the rhumb lines, which cut the meridians all at the same angle on the globe, will all be straight lines cutting them at the same angles in the projection that they do upon the globe; and the distance between any two places on the globe will be to the projected distance, as the difference of latitude of the places on the globe is to the projected or meridional difference of latitude; and the difference of latitude on the globe will be to the departure, as the projected or meridional difference of latitude is to the difference of longitude.

For let the annexed figure be the Mercator's projection of that part of the figure, p. 138, which is marked by like letters without dashes; then all the elementary triangles A *b* B, B *c* C, &c. in that figure are respectively similar to each other; and, by the nature of the projection, they are also similar to the corresponding triangles A′ *b*′ B′, B′ *c*′ C′, &c. in this figure; and as the elementary triangles A *b* B, B *c* C, &c. may be collectively represented by a similar right-angled plane triangle, whose perpendicular is equal to A F, hypothenuse to A E, and base to *b* B + *c* C, &c.; therefore the projected triangles A′ *b*′ B′, B′ *c*′ C′, &c. may be represented also by a plane triangle, similar to that by which those on the globe are represented, having A′ F′, the projected difference of latitude, for its perpendicular, F′ E′ or B′ *b*′ + C′ *c*′, &c. the difference of longitude for its base, A′ E′ the projected distance for its hypothenuse, and the angle F′ A′ E′ equal to the course.



If, therefore, in the annexed figure, A B C and A D E be two right-angled triangles, and A B be the difference of latitude, the common angle A the course, and A D the meridional difference of latitude; then B C will be the departure, or the sum of the elementary meridian distances, A C the nautical distance, and D E the difference of longitude, *all exactly*. Hence from such part



of these triangles as may be given in any case proposed for solution, the others may be obtained by computation, inspection, or otherwise.

The following obvious proportions will be found useful in practice.

1. AB : BC :: AD : DE

2. AD : DE :: rad : tan ∠ A

That is diff lat : dep :: mer diff lat : diff long.

And mer diff lat : diff long :: rad : tan . course.

We proceed now to investigate another method of finding the course and distance, first published by Mr. B. Workman. This method is in all cases accurate, and may be used in preference to the other methods when the course is large.

Let l = the proper diff lat, l' = the mer diff lat, L = the diff long, m = the lat in which the meridian dist is *exactly* equal to the departure, and C = the course. Then, by the principles of middle latitude, and Mercator's sailing, $\frac{\cos m \,.\, \mathrm{L}}{l} = \frac{\mathrm{rad}\,\mathrm{L}}{l'}$, each being = tan C. Hence $\cos m = \frac{\mathrm{rad}\,.\,l}{l'}$. The difference between m, and the middle latitude, is given in the table at the beginning of the practical article on Middle Latitude and Mercator's Sailing.

Again, by mid lat sailing, $\mathrm{dep} = \frac{\mathrm{L}\,.\,\cos m}{\mathrm{rad}}$ and by plane sailing $\mathrm{dep} = \frac{\mathrm{dist}\,.\,\sin \mathrm{C}}{\mathrm{rad}}$. Whence sin C : cos m :: L : dist.

From the preceding elementary view of the principles of navigation, it will be seen that the whole business of practical computation resolves itself into the solution of plane triangles; and that therefore navigation may be considered as only a particular application of plane trigonometry.

ON THE INSTRUMENTS BY WHICH A SHIP'S COURSE AND DISTANCE ARE DETERMINED AT SEA.

The course of a ship, or the angle which the rhumb line on which she sails makes with the meridian, is determined by an instrument called The Compass; which is merely a circular card suspended horizontally on a point, and having a magnetised bar of hardened steel, called The Needle, for one of its diameters.

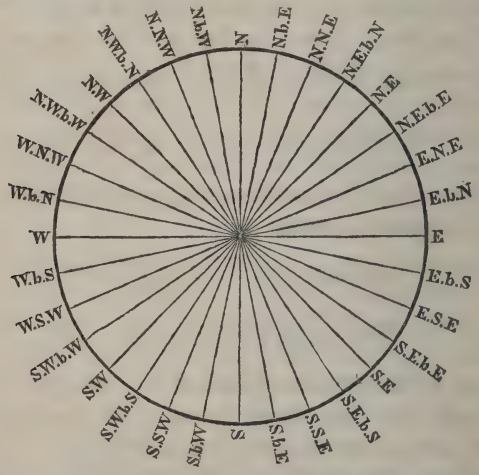
The circumference of the card is generally divided into thirty-two equal parts, called *points;* and each of those divisions is again subdivided into four parts, called *quarter points.*

A point of the compass being therefore the 32d part of the circumference of a circle, is equal to 11° 15′. But in some compasses, for

delicate observations, particularly those called azimuth compasses, the rim of the card is divided into degrees.

The magnetised needle has the peculiar property of pointing always in a particular direction, generally not far from the direction of the meridian.

That point of the card which coincides with the northerly end of the needle is called the magnetic *north*, and the opposite point the magnetic *south;* and, looking towards the north end of the needle, the middle point on the right, between the north and south, is called the *east*, and the opposite point the *west*. These four are called *cardinal points*, and the others are named according to their situation with respect to these cardinal points, as in the annexed figure.



The following Table shews the degrees, &c. corresponding to every quarter point of the compass.

Points.		Points.	
0	0° 0′ 0″	4	45° 0′ 0″
0¼	2 48 45	4¼	47 48 45
0½	5 37 30	4½	50 37 30
0¾	8 26 15	4¾	53 26 15
1	11 15 0	5	56 15 0
1¼	14 3 45	5¼	59 3 45
1½	16 52 30	5½	61 52 30
1¾	19 41 15	5¾	64 41 15
2	22 30 0	6	67 30 0
2¼	25 18 45	6¼	70 18 45
2½	28 7 30	6½	73 7 30
2¾	30 56 15	6¾	75 56 15
3	33 45 0	7	78 45 0
3¼	36 33 45	7¼	81 33 45
3½	39 22 30	7½	84 22 30
3¾	42 11 15	7¾	87 11 15
4	45 0 0	8	90 0 0

The situation of the needle with respect to the meridian is not the same at every place, nor is it always the same at the same place. At present at London the north end of the needle points about $24\frac{1}{2}^\circ$ towards the west of the true north point of the horizon, but at the North Cape it points only about 1° towards the west, while in some parts of Davis's Straits its direction is more than $6\frac{1}{2}$ points towards the west, and near Cape Horn it points about 22° towards the east of the true north.

Again, in the year 1580, the direction of the needle, at London, was about one point towards the *east* of the north, while, as has been already observed, it at present points about $24\frac{1}{2}^\circ$ towards the *west*. But in the West Indies, for a very long period, the deviation of the needle has undergone but a very trifling variation.

Delicate observations appear to indicate that it is again at London retrograding towards the east; and Mr. Barlow, in his valuable "Essay on Magnetic Attractions," observes that all the phenomena attending the progressive change of the needle's deviation from the meridian, may be accounted for by conceiving the magnetic pole to revolve in a parallel of latitude from east to west; but that every place appears to have its individual pole.

The direction of the needle, or, as it is called, the *variation of the compass*, may however be determined at any time (as will afterwards be shewn) by astronomical observations; the points of the horizon, which correspond to the several points of the compass, may therefore easily be found by allowing for the variation, when it is known.

Thus, if it be found that the north end of the needle points to the N N W point of the horizon, the compass is then said to have two points westerly variation, and the N N E point of the compass will coincide with the meridian, the east point of the compass with the E N E point of the horizon, &c.

But if the north point of the compass points to the N E by N point of the horizon, the compass is said to have three points easterly variation, and the N W by N point of the compass will coincide with the meridian, the east point of the compass with S E by E point of the horizon, &c. If, therefore, a ship is steered N W by a compass which has two points westerly variation, the angle which her way makes with the true meridian will be six points, or the ship's true course will be W N W.

Hence, when the compass course is given to determine the true course, allow the variation, if it be westerly, to the *left* of the compass course; and, if easterly, to the *right* of the compass course. On the contrary, when the true course is known, and the corresponding course s required by a compass whose variation is given, allow the variation, when it is west, to the *right* of the true course, and when east to the *left* of the true course, and the point thus determined is the required compass course.

When a needle which is balanced horizontally on a point is magnetised, it not only acquires the property of pointing in a particular horizontal direction, but it *loses its balance*, or becomes inclined to the horizon; and it requires an additional weight to be applied to the elevated end of the needle to restore it to its horizontal position. This inclination of the needle to the horizon is called the *dip;* and as it is different in different situations, a magnetised needle which is horizontal in one place may not be horizontal in another. The weight, therefore, which is a counterpoise to the dip in one place may not be so in another; and on this account needles properly fitted up for mariners' compasses have a sliding weight applied to them, to adjust them to the horizontal position at any time.

The needle, with its apparatus, is generally placed in a brass case, which being slung in gimbals, the card is always at liberty to assume a horizontal position; and in the inside of the case there are two black vertical lines, which with respect to the card are diametrically opposite to each other. The imaginary horizontal line joining these two vertical ones ought to be exactly in the vertical plane cutting the ship from stem to stern; and the point of the card which coincides with the vertical line towards the stem of the vessel indicates the direction of the ship's head, or shews her apparent course by the compass.

No iron whatever should be allowed to be near the compass. Indeed, it has been lately noticed that the whole mass of iron in a ship often exerts a perceptible influence on the direction of the needle, which varies according to the situation of the ship's head with respect to the magnetic meridian. We shall afterwards advert more particularly to this *local attraction*, when we consider the methods by which the variation of the compass may be found astronomically.

A ship's rate of sailing is estimated by heaving into the sea a piece of wood called THE LOG, so loaded with lead that it will just swim. The log is then conceived to remain stationary in the water, and a line is attached to it, called the LOG LINE, which at its other end is wound round a reel. The reel being turned, the part of the line that is withdrawn from it by the log in a given time is the distance which the ship runs from the log during that interval; and hence, by proportion, her distance for any other time may be obtained, while her rate of sailing continues the same.

The log is made in the form of a sector of a circle, and the lead with which it is loaded is applied to the arc; the central point is therefore vertical in the water.

The line is so attached to it that the flat side of the log is kept towards the ship, that the resistance of the water against the face of the log may prevent it, as much as possible, from being dragged after the ship by the weight of the line or the friction of the reel.

The time which is usually occupied in determining a ship's rate is

half a minute, and the experiment for the purpose is generally made at the end of every hour, but in common merchantmen at the end of every second hour. As the time of operating is half a minute, or the 12th part of an hour, if the line were divided into 120ths of a nautical mile, whatever number of those parts a ship might run in half a minute, she would, at the same rate of sailing, run exactly a like number of miles in an hour. The 120th part of a mile is by seamen called a *knot*, and the knot is generally subdivided into smaller parts, called *fathoms*. Sometimes (and it is the most convenient method of division) the knot is divided into ten parts; more frequently perhaps into eight; but in either case the subdivision is called a *fathom*. In ships where no great accuracy in navigation is attempted, the knot is subdivided into four parts, and sometimes only into two.

We shall, however, consider a fathom as the *tenth* part of a knot; and as a nautical mile (p. 138) is 6079 feet, the 120th part of this, or the length of a knot, will be 50·66 feet, or nearly 50 feet 8 inches. Hence a fathom ought to be 5 feet and eight tenths of an inch nearly. In practice, however, 50 feet is generally considered as sufficient for the length of a knot, for the log is always in some degree drawn towards the ship, and therefore the distance given by a correct line is always less than the true distance. The operation for estimating the rate is called by seamen *heaving the log*.

The time is measured by a sand glass, which ought of course to run out in 30 seconds. A quantity of the line, called the *stray line*, is allowed to run out before the glass is turned, that the log may be without the reach of the ship's wake. When the glass is run out, the knots, and parts of a knot between the ship and the mark at the end of the stray line, indicate the distance which the ship has run from the log in the interval of time measured by the sand glass; hence her hourly rate of sailing is known.

The time which the sand glass takes in running out, and the length of the knots of the log line, should frequently be examined; for the time by the sand glass is materially affected by the state of the atmosphere, and the log line is liable to contract from the action of the water; and it may happen that the whole line, or different parts of it, may accidentally be stretched.

If either the glass or the line, or both, be found erroneous, the error must be ascertained, and the true distance may then be found by a simple formula, which may be thus investigated.

Let k = the true length of a knot, and m = the measured length of one; t = the seconds in the same part of an hour that k is of a mile, s = the seconds run by the glass, and d = the distance as determined by these erroneous instruments.

Then $k : m :: d : \frac{d\,m}{k}$, the true distance, if the log line only were erroneous; and $s : t :: \frac{d\,m}{k} : \frac{t\,d\,m}{k\,s}$, a general expression for the true distance when the log line and the glass are both erroneous.

If $s = t$, or if the log line only is erroneous, the general expression becomes $\frac{d\,m}{k}$ as before; and if $m = k$, or the glass only is erroneous, the expression is $\frac{t\,d}{s}$. If $t = 30$ seconds, and $k = 50$ feet, we have $\frac{t\,d\,m}{k\,s} = \frac{30\,d\,m}{50\,s} = \frac{3\,d\,m}{5\,s}$, the true distance when both the log line and the glass are erroneous.

If $m = 50$ feet, or if the glass only is erroneous, this expression is $\frac{30\,d}{s}$; and if $s = 30$, or if the line only is erroneous, the expression is $\frac{d\,m}{50}$.

If t, k, and s were given to find a corresponding value of m, we have $t : s :: k : m = \frac{s\,k}{t} = \frac{5\,s}{3}$.

PRACTICAL APPLICATION OF THE PRINCIPLES OF NAVIGATION.

To find the difference of latitude or the difference of longitude between any two places whose latitudes and longitudes are given.

Rule. When the given latitudes are of the same denomination, subtract the less from the greater; but when they are of different denominations, add them together; and the sum or the remainder will be the difference of latitude.

The difference of longitude is found in the same manner; observing, however, that the difference of longitude signifies the *less* arc of the equator intercepted between two meridians; and that, therefore, when the longitudes are of different denominations, and their sum exceeds 180°, that the sum must be subtracted from 360° to find the difference of longitude.

Examples.

Required the difference of latitude and difference of longitude between the Lizard Point and the Peak of Pico?

Lizard Point lat.....49° 58′ N
Pico lat.....38 28 N

diff lat 11 30 = 690 miles.

Lizard Point long ..... 5° 11′ W
Pico long ..... 28 33 W

diff long 23 22 = 1402 miles.

Required the difference of latitude and difference of longitude between Halifax and the Cape of Good Hope?

Halifax lat ..... 44° 44′ N
Cape of Good Hope lat ..... 34 29 S

diff lat 79 13 = 4753 miles.

Halifax long ..... 63° 36′ W
Cape of Good Hope long ..... 18 23 E

diff long 81 59 = 4919 miles.

Required the difference of latitude and difference of longitude between Cape Horn and South Cape, Van Diemen's Land?

Cape Horn lat ..... 55° 58′ S
South Cape lat ..... 43 37 S

diff lat 12 21 = 741 miles.

Cape Horn long ..... 67° 21′ W
South Cape long ..... 146 49 E

214 10
360 0

diff long 145 50 = 8750 miles.

Examples for Exercise.

Required the difference of latitude and difference of longitude between the following places?

1. Between Cape Amber, in Madagascar, and Bombay?
   Answer, diff lat 1851, and diff long 1422 miles.
2. Between Dondre Head, in Ceylon, and Socotra?
   Answer, diff lat 407 and diff long 1645 miles.
3. Between Savannah and Cape Clear?
   Answer, diff lat 1165, and diff long 4288 miles.
4. Between Cape Padaran and Cayenne?
   Answer, diff lat 670, and diff long 3898 miles.
5. Between Algiers and Genoa?
   Answer, diff lat 457, and diff long 351 miles.

To find the latitude and longitude at which a ship has arrived, when those of the place which she left, and the difference of latitude and longitude which she has made, are given.

Rule. If the latitude left and the difference of latitude are of the same denomination, add them together; but if they are of different

denominations, take their difference; and the sum or the remainder is the latitude arrived at, and of the same denomination with the greater.

Remark. As no place can be farther distant from the equator than the *poles*, the latitude cannot exceed 90°.

The longitude arrived at is found in the same manner as the latitude; but as the longitude is reckoned both *east* and *west*, if the longitude left and the difference of longitude are of the same denomination, and their sum exceeds 180°, the difference between the sum and 360° is the longitude arrived at, and of a contrary denomination to the longitude left.

Examples.

If a ship sail from Cape Finisterre towards the south-west till her diff of lat is 140, and her diff of long 118 miles, required her latitude and longitude in?

Cape Finisterre lat	42°	54′ N	Long left.....	9°	16′ W
diff lat 140 =	2	20 S	diff long 118 =	1	58 W
lat in	40	34 N	long in	11	14 W

If a ship sail from lat 50° 18′ S long 178° 21′ E towards the S E till her diff lat is 638 and her diff long 400 miles, required her latitude and longitude in?

Lat left.....	50°	18′ S	Long left.....	178°	21′ E
diff lat 638 =	10	38 S	diff long 400 =	6	40 E
lat in	60	56 S		185	01
				360	0
			long in	174	59 W

Examples for Exercise.

In the following examples the latitude and longitude arrived at are required.

	Lat left.	Long left.	Diff lat. Miles.	Diff long. Miles.	Answer. Lat. in.	Long in.
1.	48° 2′ S	16° 34′ W	149 N	218 E	45° 33′ S	12° 56′ W
2.	55 18 N	2 18 E	80 N	162 W	56 38 N	0 24 W
3.	48 30 N	30 6 W	175 S	260 W	45 35 N	34 26 W
4.	0 0	0 0	238 N	141 W	3 58 N	2 21 W
5.	64 2 N	3 13 W	304 S	158 E	58 58 N	0 35 W
6.	39 37 S	28 17 E	112 S	300 E	41 29 S	33 17 E

To know in what quarter of the horizon the course between any two places lies.

Rule. If the place bound to has greater north latitude, or less south latitude, than the place to be sailed from, the course will be northerly; otherwise it will be southerly. And if the place bound to has greater

east longitude, or less west longitude, than the place to be sailed from, the course will be easterly; otherwise it will be westerly. These directions combined will indicate the quarter in which the course lies.

Example.

In what quarter of the horizon will the course lie from lat 28° N long 16° W to lat 35° N long 2° W?

Here the place bound to has greater north lat than the place to be sailed from; the course, therefore, is *northerly*. And as the place bound to has less west long than the place to be sailed from, the course is also easterly. The course is therefore between the *north* and *east*, or in the *north-east* quarter of the horizon.

In what quarter of the compass will the course lie in sailing from the first to the second of each of the following places?

1. From Aberdeen to Rotterdam? Answer, in the S E quarter.
2. From the Lizard to Halifax? Answer, in the S W quarter.
3. From the Cape of Good Hope (Africa) to Van Diemen's Land? Answer, in the S E quarter.
4. From Cape Horn to St. Helena? Answer, in the N E quarter.
5. From Lisbon to Cape Farewell (Greenland?) Answer, in the N W quarter.
6. From the Cape of Good Hope (Africa) to Rio Janeiro? Answer, in the N W quarter.

To correct the distance given by the log and half minute glass, for errors in the line and glass.

General Rule. Multiply the given distance by six times the measured length of a knot, and divide the product by ten times the seconds which the glass takes in running out, and the quotient will in any case be the true distance.

Examples.

A ship runs 126 miles, but it is found on examination that the length of the knots on the log line is 52 feet, and that the glass runs out in 27 seconds: required the true distance?

$$\begin{array}{rr} & 126 \\ 6 \times 52 = & 312 \\ \hline & 252 \\ & 126 \\ & 378 \\ \hline & 39312 \\ 27 \times 10 = & 270 \end{array} = 145{\cdot}6$$

Examples for Exercise.

In the following examples the true distance is required.

	Dist. by log. Miles	Length of knots. Feet.	Seconds by glass. Seconds.	Answer. True distance.
1.	87	48	26	96
2.	218	53	31	224
3.	146	46	28	144
4.	159	52	27	184
5.	46	51	28	50
6.	102	48	28	105

When the true course and the variation of the compass are given, to find the compass course.

Rule. If the variation be west, allow it to the right, but if east, allow it to the left of the true course, and the point thus determined is the required compass course.

Example.

The true course from the Lizard to St. Mary's is S W $\frac{3}{4}$ W, and the variation of the compass at the Lizard is $2\frac{3}{4}$ W: what is the compass course?

Answer, $2\frac{3}{4}$ points allowed to the right if S W $\frac{3}{4}$ W gives W $\frac{1}{2}$ S, the required compass course.

Examples for Exercise.

In the following examples the compass courses are required.

	True Course.	Variation, Points.	Answer. Compass Course.
1.	N E b N	$2\frac{1}{4}$ W	N E b E $\frac{1}{4}$ E
2.	N W	5 W	N b E
3.	N N W	$3\frac{1}{4}$ E	N W b W $\frac{1}{4}$ W
4.	S $\frac{1}{2}$ E	$1\frac{3}{4}$ W	S b W $\frac{1}{4}$ W
5.	S S W $\frac{3}{4}$ W	$4\frac{1}{2}$ E	S b E $\frac{3}{4}$ E
6.	W	2 W	W N W
7.	E b S	$6\frac{1}{2}$ E	N N E $\frac{1}{2}$ E
8.	S 18° E	24° E	S 42° E
9.	S 46 W	22 W	S 68 W
10.	N 31 W	13 E	N 44 W

When the course which a ship has steered by the compass, and the variation of the compass are given, to find the true course.

If the variation be west, allow it to the left, but if east, allow it to the right of the compass course, and you have the true course corresponding to that given by the compass.

EXAMPLE.

If a ship be steered N N W by a compass which has $1\frac{1}{2}$ points westerly variation, required her true course?

Answer, $1\frac{1}{2}$ points allowed to the left of N N W gives N W $\frac{1}{2}$ N for the true course.

EXAMPLES FOR EXERCISE.

In the following examples the true courses are required.

	Compass Course.	Variation, Points.	Answer. True Course.
1.	S S E $\frac{3}{4}$ E	2$\frac{1}{4}$ W	S E b E
2.	E $\frac{1}{2}$ N	3 E	E S E $\frac{1}{2}$ S
3.	N W b W	3$\frac{3}{4}$ E	N b W $\frac{1}{4}$ W
4.	W S W $\frac{1}{2}$ S	4 W	S b W $\frac{1}{2}$ W
5.	S S W	1$\frac{1}{2}$ W	S $\frac{1}{2}$ W
6.	N	5 E	N E b E
7.	E b S	2$\frac{1}{4}$ E	S E $\frac{3}{4}$ E
8.	S 60° E	18° W	S 78° E
9.	N 24 W	36 E	N 12 E
10.	S 16 W	40 E	S 56 W

OF LEEWAY.

THE angle included between the direction of the fore and aft line of a ship, and that in which she moves through the water, is called the *leeway*.

When the wind is on the right-hand side of a ship, she is said to be on the *starboard* tack; and when on the left-hand side, she is said to be on the *larboard* tack; and when she sails as near the wind as she will lie, she is said to be *close hauled*. Few large vessels will lie within less than six points of the wind, though small ones will sometimes lie within about five points, or even less; but, under such circumstances, the real course of a ship is seldom precisely in the direction of her head; for a considerable portion of the force of the wind is then exerted in driving her to leeward, and hence her course through the water is in general found to be leeward of that on which she is steered by the compass. Therefore, to determine the point towards which a ship is actually moving, the leeway must be allowed *from the wind*, or towards the *right* of her apparent course, when she is on the *larboard* tack; but towards the *left* when she is on the *starboard* tack.

It is evident that the track which a ship leaves on the water, or the *wake*, as the track is called, will lie directly opposite to the point towards which she is moving, whatever way her head may lie. If, therefore, the figure of a compass were drawn in any convenient

situation, so that its meridian were parallel to the fore and aft line of the ship, the angle included between the meridian of this compass and that point of it which was directed towards the wake, would be the leeway; and in some such manner as this, it is desirable that the leeway should be determined when practicable

The quantity of leeway which a ship will make varies, however, under different circumstances. If all other circumstances be the same, a light ship will make more leeway than a laden one. It is seldom that two ships on the same course make precisely the same leeway; and it not unfrequently happens that the same ship makes a different leeway on each tack. It is the duty of the officer of the watch to exercise his best skill in determining, or estimating, how much this deviation from the apparent course amounts to; and *in the dark* the chief reliance must be placed on the judgment of the experienced mariner.

In estimating the leeway, there are certain rules by which mariners are often guided; and though they can only be considered as affording a general approximation to the truth, and often a very distant approximation, they are here given: but no opportunity should be neglected to determine this important element by observation.

General Rules for estimating the Leeway when a Ship is close hauled.

1. When the water is smooth, all sails set, and the wind moderate, allow no leeway.

If there be a strong breeze, the leeway may amount to 1 point.

2. When top-gallant sails are handed, the leeway may be from 1 point to $1\frac{1}{2}$ point.

3. Under close-reefed top sails, the allowance may be from 2 to 3 points.

4. With top sails handed, from 3 to 4 points.

5. Under courses, from 4 to 6 points, according to circumstances.

6. Under reefed courses, possibly 6 points.

7. Under storm stay sails, possibly 7 points.

8. Under bare poles, from 7 to 8 points.

It has not been attempted in the above rules, and indeed it is impossible, to state precisely what the allowance for leeway ought to be under all or any circumstances. This, in any given case, must be left to the judgment of the mariner, whose knowledge must extend to a number of minutiæ bearing upon the question, before he will affirm that, after exercising his best skill, he has satisfied himself that his estimate is right.

But supposing the leeway to be known, the course steered must be corrected for it; and the following examples are given as exercises in correcting the courses both for leeway and variation, *the true course being required.*

Examples for Exercise.

	Compass Course.	Tack.	Leeway Points.	Variation Points.	Answer. True Course.
1.	S E b S	Larboard	$1\frac{1}{2}$	2 W	S E $\frac{1}{2}$ S
2.	E	Starboard	3	$2\frac{1}{2}$ E	E $\frac{1}{2}$ N
3.	W N W	Starboard	$2\frac{1}{2}$	4 W	S W $\frac{1}{2}$ S
4.	S S W $\frac{1}{2}$ W	Larboard	5	3 E	N W b W $\frac{1}{2}$ W
5.	N	Larboard	$7\frac{1}{2}$	$3\frac{1}{4}$ E	S E b E $\frac{1}{4}$ E
6.	N $\frac{3}{4}$ E	Starboard	3	3 W	N W b W $\frac{1}{4}$ W
7.	N E b E	Larboard	2	2 W	N E b E
8.	S W $\frac{1}{2}$ S	Starboard	$5\frac{1}{4}$	$4\frac{1}{2}$ E	S S W $\frac{3}{4}$ W

OF PLANE SAILING.

In plane sailing the earth is considered as a plane, the meridians as parallel straight lines, and the parallels of latitude as lines cutting the meridians at right angles. And though it is not strictly correct to consider any part of the earth's surface as a plane, yet, when the operations to be performed are confined within the distance of a few miles, no material error will arise from considering them as performed on a plane surface. And, as we have already seen, in all questions where the *nautical distance*, *difference of latitude*, *departure*, *and course* are the objects of consideration, the results will be the same, whether the lines be considered as curves drawn on the surface of the globe, or as equal straight lines drawn on a plane.

In all maps, and charts, and constructions, when it is not otherwise stated, it is customary to consider the top of the page as pointing towards the north, the lower part as the south, the right side as the east, and the left as the west. The meridians, therefore, in any construction, will be represented by vertical lines, and the parallels of latitude by horizontal ones.

Hence, in constructing a figure for the solution of any case in plane sailing, the difference of latitude will be represented by a vertical line, the departure by a horizontal one, and the distance by the hypothenusal line, which forms with the difference of latitude and departure a right-angled triangle; and the course will be the angle included between the difference of latitude and distance.

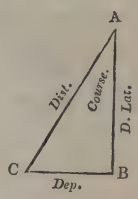
With this understanding, the solution of any case that can arise from varying the data in plane sailing, will present no difficulty.

Examples.

1. If a ship sail from Cape St. Vincent S W $\frac{1}{2}$ S 148 miles, required her latitude in, and the departure which she has made?

By Construction.

Draw the vertical line A B, to represent the meridian; from the line of rhumbs take the angle B A C = $3\frac{1}{2}$ points, the given course; and from a scale of equal parts take A C = 148 miles, the given distance; from C on A B draw the perpendicular C B, then A B will be the difference of latitude, and B C the required *departure*; and measured on the scale from which A C was taken, A B will be found 114·4, and B C 93·9.



By Inspection.

With ∠ A, $3\frac{1}{2}$ points, in Table 1, and A C 148 miles in the dist column, A B is found 114·4 in the lat column, and B C 93·9 in the dep column.

By Gunter's Scale.

Extend from 8 to $3\frac{1}{2}$ points, the course, on the line S R, and that extent will reach from 148, the dist, towards the left on the line of numbers, to the departure 93·9. Again, extend on the line S R from 8 to $4\frac{1}{2}$ points (the complement of $3\frac{1}{2}$ points), and that extent will reach from 148 towards the left on the line of numbers to 114·4, the difference of latitude.

By Calculation.

radius ..... 10·000000	radius ..... 10·000000
: A C 148 miles ..... 2·170262	: A C 148 miles ... 2·170262
: : cosin ∠ A $3\frac{1}{2}$ points 9·888185	: : sin ∠ A $3\frac{1}{2}$ points.. 9·802359
: : A B diff lat 114·4.. 2·058447	: B C dep 93·89 ... 1·972621

Lat of Cape St. Vincent....	37°	3′ N
Diff lat	1	54 S
Lat in	35	9 N

2. If a ship sail from the Cape of Good Hope southwestward, till she arrive in latitude 36° 34′ S, and it be found that upon the whole she has made 75 miles of departure, required the course and distance which she has made?

Lat of Cape of Good Hope ..	34° 24′	S
Lat in	36 34	S
Diff lat	2 10	S = 130 miles.

By Construction.

Draw A B and B C (see the last figure) perpendicular to each other, make A B = 130, and B C = 75, from a scale of equal parts, and join A C; then the ∠ A, the course, will be found = 30°, and A C, the distance, = 150 miles.

By Inspection.

In Table 2, with A B 130, in the lat column, and B C 75, in the dep column, ∠ A is found at the top of the table = 30° nearly, and A C in the dist column 150.

By Gunter's Scale.

Extend from the diff lat 130, to the dep 75, on the line of numbers; that extent will reach on the line of tangents from 45°, or *radius*, to about 30°, the course. Again, extend from radius 90° on the line of sines, to 60°, the complement of the course; and that extent will reach from 130, the diff lat towards the right, on the line of numbers, to 150, the distance.

By Calculation.

A B 130.....	2·113943	radius	10·000000
: radius	10·000000	: A B 130	2·113943
:: B C 75	1·875061	:: sec ∠ A	10·062396
tan 29° 59′.....	9·761118	A C 150·1	12·176339

Hence the course is S 29° 59′ W, and the distance 150·1 miles.

Examples for Exercise.

1. If a ship sail from Oporto, N W ¼ W 315 miles, required her departure, and the latitude she has arrived at?

Answer, dep 233·4 miles W, and lat 44° 41′ N.

2. If a ship sail from lat 55° 1′ N, S E b S, till her departure is 45 miles, required the distance she has sailed, and her latitude?

Answer, dist 81 miles, and lat 53° 54′ N.

3. A ship from lat 36° 12′ N, sails southwestward till she arrives in lat 35° 1′ N, having made 76 miles of departure, required her course and distance? Answer, course S 46° 57′ W, and dist 104 miles.

4. A ship from lat 40° 5′ N, sails S W ½ S till she arrives in lat 36° 7′ N, required her distance and departure?

Answer, dist 307·9 miles, and dep 195·3 miles W.

5. A ship from Funchal, in Madeira, sails between the south and west, till her diff lat is 114, and her dep 97 miles, required her course, distance, and latitude?

Answer, course S 40° 24′ W, dist 149·7 miles, and lat 30° 43′ N.

6. A ship sails from the Cape of Good Hope southeastward till she arrives in lat 40° 10′ S, having run 700 miles, required her course and departure? Answer, course S 60° 22′ E, and dep 608·4 miles E.

7. If a ship sail N N W ¾ W, 123 miles, from lat 18° 2′ N, required her departure and latitude arrived at?

Answer, lat 19° 47′ N, and dep 63·2 miles W.

8. If a ship from Halifax sail S E ½ E till her dep is 128 miles, required her latitude and distance?

Answer, lat 42° 59′ N, and distance 165·6 miles.

9. If a ship sail from Cape Finisterre S S W ¾ W, 234 miles, required her latitude and departure?

Answer, lat 39° 33′ N, and dep 120·3 miles W.

10. If a ship from lat 50° 16′ N, sail southeastward till her distance is 137, and her departure 112 miles, required her course and latitude come to? Answer, course S 54° 50′ E, and lat 48° 57′ N.

11. If a ship sail N W b W ½ W from lat 30° 14′ N till her departure is 204 miles, required her latitude, and the distance she has sailed?

Answer, distance 231·4 miles, and lat 32° 3′ N.

12. A ship from lat 12° 17′ N sails N E ¼ N 201 miles, required her latitude and departure? Answer, lat 14° 46′ N, and dep 135 miles E.

13. A ship sails from the North Cape, in Lapland, 200 miles, and it is then found that she is to the westward of the Cape, and 125 miles south of it, required her course, latitude, and departure?

Answer, course S 51° 19′ W, lat 69° 5′ N, dep 156·1.

14. A ship from the east point of St. Mary, Azores, sails E N E ½ E till she arrives in the lat of Lisbon, required her distance and departure?

Answer, dist 358·9, and dep 342·7.

15. A ship leaving Charleston Light, sails N eastward 128 miles, and is then by observation found 39 miles north of the light, required her course, latitude, and departure?

Answer, lat 33° 22′ N, course N 72° 16′ E, and dep 122.

16. A ship sails from Cape St. Roque N E ½ N, 7 miles an hour, from 3 P M till 10 A M, required her distance, departure, and latitude arrived at? Answer, lat 3° 27′ S, dep 84·38, and dist 133.

17. A ship from lat 41° 2′ N sails N N W $\frac{3}{4}$ W, $5\frac{1}{2}$ miles per hour for $2\frac{1}{2}$ days, required her distance, departure, and latitude arrived at?

Answer, lat 45° 45′ N, dep 169·7, and dist 330.

18. If a ship sail from lat 48° 27′ S, S W b W, 7 miles an hour, in what time will she reach the parallel of 50° S? Answer, 23·914 hours.

19. If a ship sail from Cape Horn due south 121 miles, and then due west 121 miles, required her course and distance, and the latitude which she has arrived at?

Answer, course S W, dist 171·1, and lat 58° 0′ S.

20. If after a ship has sailed from lat 40° 21′ N to lat 46° 18′ N, she be found 216 miles to the eastward of the port from whence she has sailed, required the course she has sailed, and the distance she has made? Answer, course N 31° 11′ E, and dist 417·3 miles.

TRAVERSE SAILING.

When a ship is obliged to sail on different courses, the crooked line which she describes is called a traverse, and the method of finding a single course and distance, which would have brought the ship to the same place, is called *resolving a traverse.*

A traverse is resolved by finding the difference of latitude and departure corresponding to each course and distance, and entering them in a table, of which the form will be found in the first of the following examples; taking care when the ship steers *southward* to enter the difference of latitude in the column marked S, but in the column marked N, when the course is *northward.* In like manner, when the course is *easterly* or *westerly*, the departure must be entered in the column marked E, or W, accordingly.

Thus if the course is S E b S the difference of latitude must be entered in the column S, and the departure in the column E; if the course is W $\frac{1}{4}$ N, the difference of latitude must be entered in the column N, and the departure in the column W; when the course is exactly E, W, N, or S, the whole distance will, of course, be entered in the corresponding column, E, W, N, or S. Then the difference between the sum of the numbers in the column marked N, and the sum of those in the column marked S, will be the whole difference of latitude, and of the same denomination with the greater sum; and in like manner the difference between the sum of the numbers in the columns marked E and W will be the whole departure, and of the same denomination with the greater sum.

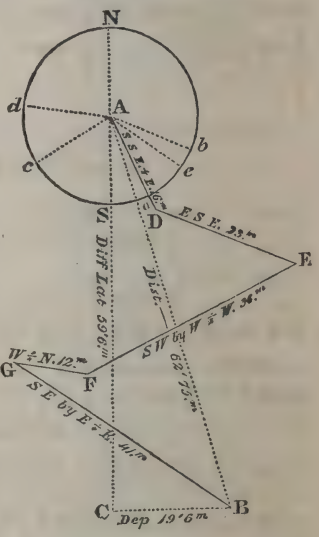
Having then obtained the whole difference of latitude and departure which the ship has made, the corresponding course and distance may be found either by inspection, or by any other method.

Example.

A ship from Cape Clear sails S S E $\frac{1}{4}$ E 16, E S E 23, S W b W $\frac{1}{2}$ W 36, W $\frac{3}{4}$ N 12, and S E b E $\frac{1}{4}$ E 41 miles, required the equivalent course and distance, and the latitude of the place which the ship has arrived at?

By Construction.

Take A for the place sailed from, and draw the vertical line N A S C to represent the meridian. About A, as a centre, with the chord of 60°, describe a circle cutting N C in N and S; then N and S will represent the north and south points of the compass. Take $2\frac{1}{4}$ points from the line of rhumbs, and apply it from S to a, join A a, and on it take A D = 16, from a line of equal parts. Then D will be the place of the ship at the end of the first course. From S set off S b = 6 points from the line of rhumbs; join A b, and through D draw D E parallel to A b, and make it equal to 23 from the same scale of equal parts that A D was taken from. Then E will be the place of the ship at the end of the second course. Make S c = $5\frac{1}{2}$ points, N d $7\frac{1}{4}$ points, and S e $5\frac{1}{4}$ points taken from the line of rhumbs. Through E draw E F parallel to A c, and make it equal to 36 from the scale of equal parts; through F draw F G parallel to A d, and make it equal to 12 from the scale of equal parts; through G draw G B parallel to A e, and make it equal to 41 from the scale of equal parts. Draw B C perpendicular to the meridian N C, and join A B; then B will be the place of the ship, A B her distance from the place which she left, A C her difference of latitude, B C her departure, and B A C the course which she has made on the whole. Now A B, A C, and B C being measured on the scale of equal parts from which the distances were taken, we have A B = 62·7, A C = 59·6, and B C = 19·6 miles. And the arc included by A B and A C, if measured on the line of chords, gives about 18° for the measure of the course B A C.



TRAVERSE TABLE.

Courses.	Dist.	Diff. Lat. N	Diff. Lat. S	Dep. E	Dep. W
S S E ¼ E	16		14·5	6·3	
E S E	23		8·8	21·3	
S W b W ½ W	36		17·0		31·8
W ¾ N	12	1·8			11·9
S E b E ¼ E	41		21·1	35·2	
Course.		1·8	61·4	63·3	43·7
S 18° E′	63		1·8	43·7	
			59·6	19·6	

Lat left ..... 51° 25′ N
diff lat ..... 1 0 S
lat in ..... 50 25 N

To find the course and distance by calculation.

Diff lat 59·6 miles....	1·775246	Radius.....	10·000000
: radius.....	10·000000	: diff lat 59·6 miles..	1·775246
:: dep 19·6 miles	1·292256	:: sec course 18° 12′..	10·022289
	11·292256		11·797535
: tan course 18° 12′..	9·517010	: dis 62·74 miles....	1·797535

Whence the course is S 18° 12′ E, and the distance 62·74 miles.

By Inspection.

Under 18° in Table 2, and adjacent to 59·9 in the *lat* column, stands 19·5 in the *dep* column, and 63 in the column of *dist*, whence the course is nearly 18°, and the distance nearly 63 miles.

By Gunter's Scale.

The extent from 59·6 to 19·6 on the line of numbers will reach from 45° on the line of tangents to the course about 18¼°, and the extent from the complement of course to radius on the line of sines will reach from the diff lat 59·6 towards the right, to the distance 63, on the line of numbers.

Examples for Exercise.

1. A ship sails from Cape Clear S b W 23, W S W 40, S W ¾ W 18, W ½ N 28, S b E 12, and S S E ¾ E 16 miles, required her course, distance, and latitude come to?

Answer, course, S 45° 47′ W, dist 102·4, and lat 50° 14′ N.

2. If a ship sail from Porto Sancto E N E 18, N E ½ E 40, N ¼ E 13, N W ¾ W 16, and N E ½ N 23 miles, required her course, distance, and latitude?

Answer, course N 34° 30′ E, dist 88·1, and lat 34° 16′ N.

3. A ship from lat 41° 12′ N sails S W b W 21, S W ½ S 31, W S W ½ S 16, S ¾ E 18, S W ¼ W 14, and W ½ N 30 miles, required her course, distance, and latitude arrived at?

Answer, course S 52° 49′ W, dist 111·7, and lat 40° 5 N.

4. A ship from the equator sails N 48, W 37, N W 18, N E 70, N N E 24, and E 32 miles, required her course, distance, and latitude in?

Answer, course N 17° 12′ E, dist 138·6, and lat 2° 12′ N.

5. If a ship sail from lat 10° 6′ S, N N E 86, N 74, E b N 53, N N W ½ N 40, and E N E ¼ N 21 miles, required her course, distance, and latitude in?

Answer, lat in 6° 34′ S, course N 23° 25′ E, and dist 231 miles.

6. A ship sails from lat 4° 5′ N, S S W 112, S b E 86, S b W 86, S S E 112 miles, required her course, distance, and latitude arrived at?

Answer, lat in 2° 11′ S, course S, dist 375·6 miles, being the same as the diff lat.

7. Last noon we were in lat 28° 46′ S, and since then we have sailed S W ¾ W 62, S b W 16, W ¼ S 40, S W ¾ W 29, S b E 30, and S ¾ E 14 miles, required the course and distance which we have run, and our present latitude?

Answer, lat in 30° 41′ S, course S 43° 14′ W, and dist 158 miles.

8. If a ship sail from lat 51° 12′ S, W 68, N 70, N W 120, and N W ½ N 100 miles, required the equivalent course and distance, and the latitude in?

Answer, lat in 47° 20′ S, course N 42° 58′ W, and dist 317·2 miles.

9. If a ship sail from lat 55° 4′ N, S E b E 24, S E b S 46, S E ½ S 31, E b N 14, and E ½ S 13 miles, required her course, distance, and latitude in?

Answer, lat in 53° 50′ N, course S 51° 7′ E, and dist 118 miles.

10. If a ship sail from Halifax E ½ S 23, S E b E 30, E b N 45, and N E ¾ N 25 miles, required her latitude in, and course and distance made good?

Answer, lat in 44° 54′ N, course N 84° 42′ E, and dist 107 miles.

11. Yesterday, on leaving the Lizard, the land bore from us N E 18 miles, since that time we have sailed W S W 14, S W b W 26, S W ½ S 37, S S W ¼ W 29, and W 15 miles, required our present latitude, and the course and distance which we have made?

Answer, latitude 48° 31′ N, course S 48° 20′ W, and distance 131 miles.

12. On leaving the Cape of Good Hope for St. Helena, we took our departure from Cape Town bearing S E b S 12 miles; after run-

ning N W 36, and N W b W 140 miles, required our latitude in, and the course and distance which we have made?

Answer, lat in 32° 3′ S, course N 52° 41′ W, and distance 187 miles.

ON PLYING TO WINDWARD.

When the wind blows so near the point towards which a ship is bound that she is obliged to steer on different tacks, it becomes a question how far she ought to steer on each tack to reach her port, or to avoid any danger that may lie in her way. Questions of this kind however are very simple; for, with a given wind, the course of a ship, close hauled, on either tack, is easily found; *and she must steer on one of the tacks till the bearing of the place which she wishes to reach is the same as the course on the other tack, if she reach the place in two boards.* When the bearing of the port is given, the angle which the course of the ship on either tack makes with that bearing is known; and hence when the distance of the port is also given, the distance on each tack will be obtained by the resolution of a plane triangle, of which one side (the given distance) and all the angles are given, to find the other two sides. This computation may be conveniently made by the following rule, which obviously results from what has here been said. *As the sine of the angle included between the two courses is to the given distance, so is the sine of the angle included between the bearing of the port and the course on either tack to the distance to be sailed on the other tack.* Thus if a port bear W N W 20 miles, and the wind blows from W b S, and the ship can lie within 6 points of the wind, then the course which she can make close hauled on the larboard tack will be N W b N, and on the starboard tack S b W, and she may be steered on either tack that is most convenient till the bearing of the port be the same as the course on the other tack. The first of these courses makes an angle of 3 points with the bearing of the port, the second makes an angle of 9 points, and the angle included between the two courses is 12 points.

Hence sin 12 points : 20 miles :: sin 3 points : 15·71 miles, the distance to be run on the starboard tack.

And sin 12 points : 20 miles :: sin 9 points : 27·74 miles, the distance to be run on the larboard tack.

It may be observed that whatever number of boards it may be found expedient that a ship should make, the *sum* of the distances on each tack will be the same as if the place had been reached on two boards only.

Examples for Exercise.

1. A ship which can lie within 5 points of the wind is bound to a port bearing S ½ E 18 miles, the wind being at S E; required her course and distance on each tack to reach her port, close hauled, in two boards?

Answer, on the larboard tack S b W 19·39 miles, and on the starboard tack E b N 5·656 miles.

2. Wanting in two boards to reach the mouth of a river, which bore N W ½ W 10 miles, I found my ship could lie within 5½ points of the wind (then at N N W) on either tack, but that on the larboard tack she made ½ point leeway, while on the starboard tack she made 1½ points, required the course and distance on each tack?

Answer, on the starboard tack W b S 17·91 miles, and on the larboard N E 13·91 miles.

3. Wishing to go round a point, which bore N N W 15 miles, but the wind being at W b N, I was obliged to ply to windward; I found my ship would make way within 6 points of the wind, required the course and distance on each tack?

Answer, on the larboard tack N b W 17·65, and on the starboard S W b S 4·138 miles.

4. If a ship can lie within 6 points of the wind on the larboard but within 5½ points on the starboard tack, required her course and distance on each tack to reach a port lying S b E 22 miles, the wind being at S W?

Answer, on the starboard tack S b E ½ E, 23·66, and on the larboard W N W 2·79 miles.

5. From a ship, A, the mouth of a river bore N N E, and from another, B, it bore N b W, distant from each 18 miles. If each ship can lie within 5 points of the wind, and sail with the given wind, close hauled, 4 miles an hour, which will reach the harbour sooner, and how much, the wind being at N?

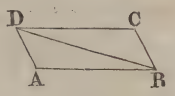
Answer, A will reach the river about 27 minutes 43 seconds before B.

6. The wind is at W S W, and a ship sailing within 5 points of it 2½ miles per hour, makes on each tack 2½ points leeway, in what time will she advance 30 miles directly to windward?

Answer, in 5 days 2 hours and 25 minutes.

OF SAILING IN CURRENTS.

If a ship at B, sailing in the direction B A, were in a current which would carry her from B to C in the same time that in still water she would sail from B to A, then, by the joint action of the current and the wind, she would in the same time describe the diagonal B D of the parallelogram A B C D. For her being carried by the current in a direction parallel to B C would neither alter the force of the wind, nor the position of the ship, or the sails, with respect to it; the wind would therefore continue to propel the ship in a direction parallel to A B, as if the current had no existence. Hence, as she would be swept to the line C D by the independent action of the current, in the same time that she reached the line A D by the independent action of the wind on her sails, she would be found at D, the point of intersection of the lines A D and C D, having moved along the diagonal B D.



Now the log heaved from the ship in the ordinary way can give no intimation of a current; for the line withdrawn from the reel is only the measure of what the ship sails *from the log;* and, consequently, as the log itself as well as the ship will move with the current, the distance shewn by the log in a current is merely what it would have been if the ship had been in still water.

The velocity and direction of a current at sea, or its *drift* and *setting*, are generally determined by heaving the log from a boat; having first, by means of a line, sunk a pot loaded with iron, or some heavy piece of metal, to a considerable depth, by which means the boat is kept nearly stationary, Then the line withdrawn by the log in a given time is evidently the measure of the current's drift in the same time; and the direction in which the current carries the log is the direction or setting of the current.

If the ship sail in the direction of the current the whole effect of the current will be to increase the distance; but if she sail against the current, the difference between the rate of sailing given by the log and the drift of the current will be the distance which the ship actually goes; and she will move forward if her rate of sailing be greater than the drift of the current, but otherwise her motion will be retrograde, or she will be carried backwards in the direction of the current.

Problems relating to the oblique action of a current upon a ship may be resolved by the solution of an oblique-angled plane triangle, such as

A B D in the above figure, where if A B represent the distance which a ship would sail in still water, and A D the drift of the current in the same time, B D will be the actual distance sailed, and A B D the change in the course produced by the current.

A great variety of problems might be proposed relative to currents, but the chief ones of any practical importance are the following.

1. To determine a ship's actual course and distance in a current, when her course and distance by the compass and the log, and the setting and drift of the current are given.

2. To find the course to be steered through a known current, the required course in still water, and the ship's rate of sailing being known.

3. To find the setting and drift of a current, from a ship's actual place, compared with that deduced from the compass and the log.

The first of these cases may be conveniently resolved, by considering the ship as having performed a traverse, the setting and drift of the current being taken as a separate course and distance, and the others by the resolution of an oblique-angled triangle.

EXAMPLE.

If a ship sail W 28 miles in a current, which in the same time carries her N N W 8 miles, required her true course and distance?

First solution, by direct computation from the oblique-angled triangle.

Let B A, in the above figure, represent the distance run by the log, and A D the drift of the current, then the angle B A D will be 10 points, and consequently half the sum of the angles A B D and A D B will be 3 points. Hence A B + A D (36) : A B − A D (20) :: tan 3 points : tan 20° 22′, half the difference of the angles A D B and A B D, whence A B D is 13° 23′, which allowed from the west towards the north gives the course N 76° 37′ W. And as sin A B D (20° 22′) : A D (8) :: sin B A D (10 points) : B D 31·93, the true distance.

Second, by the Traverse Table.

Course.	Dist.	Diff. Lat.		Dep.	
		N	S	E	W
W	28				28
N N W	8	7·39			3·06
		7·39			31·06

As 7·39 : rad : : 31·06 : tan 76° 37′, the course,
rad : cosec 76° 37′ : : 31·06 : 31·93, the distance.

Examples for Exercise.

1. If a ship sail E 7 miles an hour by the log, in a current setting E N E 2·5 miles per hour, required her true course and hourly rate of sailing? Answer, course N 84° 8′ E, and rate 9·358 per hour.

2. A ship has made by the reckoning N ½ W 20 miles, but by observation it is found that, owing to a current, she has actually gone N N E 28 miles, required the setting and drift of the current in the time which the ship had been running?

Answer, setting N 64° 48′ E, and drift 14·1 miles.

3. A ship's course to her port is W N W, and she is running by the log 8 miles an hour, but meeting with a current setting W ½ S 4 miles an hour, what course must she steer in the current that her true course may be W N W? Answer, course N 53° 51′ W.

4. In a tide running N W b W 3 miles an hour, I wished to weather a point of land which bore N E 14 miles, what course must I steer so as to clear the point, the ship going 7 miles an hour by the log, and what time shall I be in reaching the point?

Answer, course N 69° 51′ E, and time 2 hours 25 minutes.

5. From a ship in a current steering W S W 6 miles an hour by the log, a rock was seen at 6 in the evening, bearing S W ½ S 20 miles. The ship was lost on the rock at 11 P.M., required the setting and drift of the current?

Answer, setting S 75° 10′ E, and drift 3·11 miles per hour.

6. If a ship sail due W 8·5 miles per hour by the log, in a current setting S W b W 4 miles per hour, required her true course, and hourly rate of sailing?

Answer, course S 79° 21′ W, and rate 12·04 miles per hour.

PARALLEL SAILING.

In the preceding problems the earth has been considered as a plane; we now proceed to the solution of problems in which it is necessary to advert to the spherical form of the earth, which we must do in all problems in which longitude is concerned.

In parallel sailing the distance of two meridians on a given parallel, the latitude of that parallel, and the distance of the meridians at the equator, or the difference of their longitudes, are the quantities whose relations are the object of computation.

It has already been shewn (page 140), that if the base of a right-angled plane triangle represent the distance of two meridians, on a

parallel whose latitude is the measure of the acute angle at the base of the triangle, the hypothenuse will represent the distance of the meridians at the equator, or the difference of their longitudes.

Hence by the solution of a right-angled triangle, when any two of these quantities are given, the other may readily be found; it may however be convenient to recollect the following proportions, viz.

1. rad : diff long :: cos lat : mer dist;
or cos lat : mer dist :: rad : diff long;
or diff long : rad :: mer dist : cos lat;

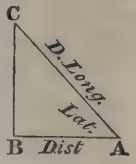
2. cos any lat : mer dist in that lat :: cos any other lat : mer dist in that other lat.

Examples.

1. If a ship sail from Cape Finisterre west 196 miles, required her longitude?

By Construction.

Make the angle A = 42° 54′, the latitude of Cape Finisterre, and from a scale of equal parts take A B=196, the given meridian distance; let B C, perpendicular to A B, meet A C in C; then A C measured on the scale of equal parts will be found to be 268, the required difference of longitude.



By Inspection.

To the angle A, nearly 43°, in Table 2, and A B, 196, in the *lat* column, corresponds A C, 268, in the *dist* column.

By Gunter's Scale.

Extend on the line of sines from 47° 6′, the complement of the latitude, to radius, 90°, and that extent will reach on the line of numbers from 196, the meridian distance, towards the right to 268, the difference of *longitude*.

By Calculation.

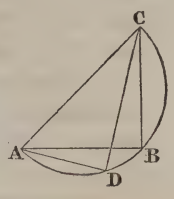
As radius.....	10·000000
: A B 196.....	2·292256
:: sec ∠ A 42° 54′	10·135167
: A C 267·6	2·427423

Longitude Cape Finisterre..	9°	16′ W
diff long.....	4	28 W
long in	13	44 W

2. If a ship sail E 126 miles from the North Cape, in Lapland, and then due N till she arrives in lat 73° 26′ N, how far must she sail W, to reach the meridian of the North Cape?

By Construction.

Make A B = 126 the given distance sailed from the North Cape, and the ∠ B A C = 71° 10′ the *lat* of the North Cape, and draw B C perpendicular to A B; then A C will be the *diff long*. On A C describe a semicircle, and from A draw A D, making the angle C A D = 73° 26′, the latitude in which the ship sailed W, meeting the semicircular arc in D, then A D will be the required distance, 111.



By Inspection.

In Table 2, with the angle C A B, nearly 71°, and A B 126 in the *lat* column, the *diff long* A C is found = 387 nearly in the *dist* column. Then with C A D nearly 73½°, and 387 in the dist column, D A the required distance is found = 110 nearly in the *lat* column.

Note. As the given numbers are too great to be found in their respective columns, the half of each number may be sought for, and the corresponding result doubled to obtain the required number.

By Gunter's Scale.

Extend from 18° 50′, the complement of the latitude of the North Cape to 16° 34′, the complement of the other given latitude on the line of sines, and that extent will reach in the same direction on the line of numbers from 126, the given meridian distance in the latitude of the North Cape to 111·3, the corresponding meridian distance in the other latitude.

By Calculation.

As cos B A C 71° 10′.....	9·508956
: A B 126	2·100371
:: cos D A C 73° 26′	9·455044
	11·555415
: A D required dist 111·3 ..	2·046459

Examples for Exercise.

1. How far must a ship sail W on the parallel of 60° to change her longitude 2°? Answer, 60 miles.

2. If a ship sail E from Cape Race 212 miles, required her longitude? Answer, 47° 54′ W.

3. Two places in lat 50° 12′ diff in long 34° 48′, required their meridian distance? Answer, 1336 miles.

4. If a ship sail from the Naze, in Norway, due W 78 miles, required her longitude? Answer, 4° 36′ E.

5. How far must a ship sail W from Cape Town that her course to James Town, St. Helena, may be due north? Answer, 1203 miles.

6. A ship in south latitude sails on a parallel 189 miles, and another in north latitude sails on a parallel 230 miles, they have both made the same diff long, 267 miles, required their difference of latitude?

Answer, 75° 27′, or 4527 miles.

7. Two ships in the same north latitude, but 126 miles distant from each other, sail S 248 miles, and their distance from each other is then 200 miles, required the latitude left, and the latitude arrived at?

Answer, lat left 83° 2′ N, and lat arrived at 78° 54′.

8. The master of a West Indiaman, in long 16° 12′ W, bound for Ireland, determines to take the shortest distance to the parallel of Cape Clear; when he is arrived in that parallel what will be his distance from the Cape? Answer, 251·3 miles.

9. How far must a ship sail E from Cape Horn, to reach the meridian of the Cape of Good Hope? Answer, 2884 miles.

10. In what latitude will a ship's diff long be three times the distance which she sails upon a parallel? Answer, 70° 31′ 44″.

MIDDLE LATITUDE AND MERCATOR'S SAILING.

By Plane Sailing, as we have seen, we determine the relations which connect the nautical distance, difference of latitude, departure, and course, and compute one from the others; and by *parallel sailing*, as we have also seen, the distance sailed on a parallel, the latitude of the parallel, and the corresponding difference of longitude, may be determined from each other.

Middle Latitude and Mercator's Sailing are two different methods of determining the relation between a ship's change of place, and her difference of longitude, when she sails on an oblique rhumb.

When the latitudes are both N or both S, half their sum is the middle latitude; but when one is north and the other south, half their difference is the middle latitude.

In Middle Latitude Sailing, the departure computed by plane sailing is considered as a meridian distance in the middle latitude, and the difference of longitude, on that supposition, is computed as in *parallel sailing*. For, the departure being taken as the base of a right-angled plane triangle, and the middle latitude as the acute angle adjoining the base, the hypothenuse of the triangle is nearly equal to the difference of longitude.

This method of deducing the difference of longitude is slightly

erroneous, because the departure is not strictly equal to the meridian distance in the middle parallel; but it will scarcely produce any material error in computing the difference of longitude for an ordinary day's run; and in any case when the course is nearly east or west, it is *safer* to compute the difference of longitude by this method than by Mercator's sailing; for a small mistake in the course by account will, under such circumstances, produce an error of much greater importance in the difference of longitude computed by Mercator's sailing, than any that can arise from the trifling error in the assumption on which middle latitude sailing is founded.

The following proportions, which have been previously deduced, will readily suggest themselves from a consideration of the figure, p. 142:

cos mid lat : dist :: sin course : diff long,
diff lat : diff long :: cos mid lat : tan course,
rad : diff long :: cos mid lat : dep,
diff lat : dep :: rad : tan course,
rad : diff lat :: sec course : dist,
rad : dep :: cosec course : dist.

Of the two proportions for the distance the latter is preferable, when the course is *very large*.

These proportions may be varied so as to find any term that may be required.

In Mercator's Sailing the difference of longitude is computed by considering the meridians as parallel lines, and of course all the parallels of latitude as equal to the equator. But the elementary parts of the meridian are also conceived to be increased in the same proportion as their parallels of latitude are; so that the *proportion* between the elementary parts of the meridians and their parallels remains unaltered. The increased meridian between the two parallels is called the *meridional difference of latitude*, in contradistinction to the actual distance of the parallels, which is called the *proper difference of latitude*. The meridional difference of latitude is obtained by taking the *difference* of the meridional parts corresponding to each latitude from Table 3, when the latitudes are of the *same* name, but their *sum*, when the latitudes are of *different* names.

Then, if a triangle be constructed similar to that formed by the difference of latitude, departure, and nautical distance, in plane sailing, having the side adjacent to the course equal to the meridional difference of latitude, the side opposite to the course will be the difference of longitude; and the different parts of these triangles may be computed from each other. (*See the second fig., p.* 144.)

It may be useful in practice to recollect the following proportions:

prop diff lat : dep :: mer diff lat : diff long,
mer diff lat : rad :: diff long : tan course,
rad : prop diff lat :: sec course : distance.

When the course exceeds 5 points, it is preferable to employ the middle latitude method. But when the diff long is *very* considerable, and the diff lat small, the following method of finding the course and distance may be employed with advantage, as in all cases it produces accurate results. (*See page* 145.)

To the middle latitude add the number from the following table, and the sum will be the latitude of the parallel in which the meridian distance is exactly equal to the departure: call this the true middle latitude.

Then, to find the course,

diff lat : diff long :: cos true mid lat : tan course.

To find the distance,

sin course : cos true mid lat :: diff long : distance.

TABLE OF CORRECTIONS, TO BE ADDED TO THE MEAN MIDDLE LATITUDE TO FIND THE TRUE MIDDLE LATITUDE.

Mid Lat.	Difference of Latitude.																	
	1°	3°	5°	7°	8°	9°	10°	11°	12°	13°	14°	15°	16°	17°	18°	19°	20°	
°	′	′	′	′	′	′	′	′	′	′	′	° ′	° ′	° ′	° ′	° ′	° ′	
15	0	2	4	9	12	15	19	23	27	31	35	0 40	0 45	0 51	0 58	1 6	1 14	
18	0	2	4	8	11	14	17	20	24	27	31	0 36	0 41	0 46	0 52	0 58	1 6	
21	0	2	4	7	9	12	15	17	20	24	28	0 32	0 36	0 41	0 46	0 51	0 56	
24	0	2	4	7	9	11	14	16	19	23	27	0 31	0 35	0 39	0 44	0 48	0 53	
30	0	2	4	6	8	10	13	15	18	21	25	0 28	0 32	0 36	0 41	0 45	0 50	
35	0	2	4	6	8	10	13	15	18	21	24	0 27	0 31	0 35	0 40	0 44	0 49	
40	0	2	4	6	8	10	13	15	18	22	25	0 28	0 32	0 36	0 41	0 45	0 50	
45	0	2	4	7	9	11	14	16	19	23	27	0 31	0 35	0 39	0 43	0 47	0 52	
50	0	2	4	7	9	11	14	17	21	24	28	0 32	0 36	0 41	0 46	0 52	0 58	
55	0	2	4	8	10	13	16	19	23	26	30	0 35	0 40	0 45	0 51	0 57	1 3	
58	0	2	4	9	11	14	17	21	25	29	33	0 38	0 44	0 50	0 55	1 2	1 8	
60	0	2	4	9	12	15	19	23	27	31	35	0 40	0 46	0 52	0 59	1 6	1 13	
62	0	2	5	9	12	16	20	24	28	32	37	0 42	0 49	0 56	1 3	1 10	1 18	
64	0	2	6	9	13	17	21	25	29	34	40	0 46	0 53	1 0	1 7	1 14	1 24	
66	0	2	6	10	14	18	22	26	31	37	43	0 50	0 58	1 5	1 12	1 21	1 31	
68	0	2	6	11	15	19	24	28	34	40	48	0 55	1 2	1 10	1 19	1 30	1 39	
70	0	3	6	13	17	21	26	31	38	44	52	1 0	1 8	1 17	1 28	1 39	1 50	
72	0	4	8	14	19	23	29	35	42	49	58	1 6	1 16	1 27	1 38	1 50	2 4	

Examples.

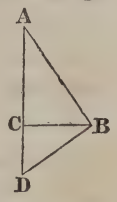
1. Required the course and distance from the east point of St. Michael's, Azores, to the Start?

Start	lat	50° 13′ N	mer parts	3495	long ..	3° 38′ W
St. Michael's..	lat	37 48 N	.....	2453	long ..	25 13 W
diff lat = 745 miles		12 25 N	mer diff lat	1042	diff long	21 35 W
	2)	88 1				60
Mean mid lat		44 1			miles	1295
Corr. from table		20				
True mid lat		44 21				

By Middle Latitude Sailing.

Construction of the figure.

Draw the meridian line A D, and at the point A make an angle B A C equal to the complement of the true middle latitude, 45° 39′; from A on A B lay off 1295 miles, the diff long; from B let fall the perpendicular B C on A D, then B C will be the mer dist in the mid lat, or the departure. Produce A C until C D be equal to 745 miles, the diff lat, and join D B, which will be the distance, and the angle D will be the course.



Hence D B, measured on a line of equal parts, will be 1189 miles, and ∠ D the course N $51\frac{1}{4}$° E.

By Inspection.

With the mid lat $44\frac{1}{3}$° as a course, and diff long 1295 miles as a distance, the dep is found in the lat column to be 930 miles. Then, with diff lat 745 miles, and dep 930 miles, in their proper columns, the course is N $51\frac{1}{4}$° E, and dist 1189 miles.

By Gunter's Scale.

Extend from rad to $45\frac{2}{3}$°, the comp of true mid lat, on the line of sines, that extent will reach from the diff long 1295 miles to the dep 930 miles on the line of numbers. Extend from this dep to 745 miles, the diff lat on the line of numbers, and that extent will reach from rad, or 45°, to the course, about $51\frac{1}{4}$°, on the line of tangents. Extend from rad to the comp of the course, on the line of sines, that extent will reach from the diff lat to the dist 1189 on the line of numbers.

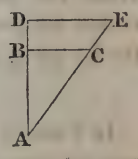
By Calculation.

Diff lat 745	2·872156	rad	10·000000
: diff long 1295	3·112270	: diff lat 745	2·872156
: : cos true mid lat 44° 21′	9·854356	: : sec course	10 202850
	12·966626	Dist 1189	3·075006
Course N 51° 11′ E tan	10·094470		

The same by Mercator's Sailing.

Construction of the figure.

Draw the vertical line A D, on which lay off A D 1042 miles, the mer diff lat, at D erect a perpendicular, and on it take D E 1295 miles, the diff long. From A on A D lay off A B 745 miles, the proper diff lat, draw B C parallel to D E, and join A E, cutting B C in C, then A C will be the distance, ∠ A the course, and B C the departure.



A C measured on a line of equal parts will be found 1189 miles, and ∠ A measured by the scale of chords will be found about 51¼°. Hence the dist is 1189 miles, and the course N 51¼° E.

By Inspection.

In Table 2, with the mer diff lat 1042 miles in the lat column, and the diff long 1295 miles in the dep column, the course is found at the bottom of the page to be between 51° and 52°, or nearly 51¼°, with this course, and the proper diff lat in the lat column, the dist is found to be about 1189 miles.

By Gunter's Scale.

Extend from the mer diff lat 1042 miles to the diff long 1295 on the line of numbers, that extent will reach from rad to the course 51¼° on the line of tangents. Extend from rad to the comp of the course on the line of sines, and that extent will reach from the proper diff lat 745 miles (towards the right) to the dist 1189 miles on the line of numbers.

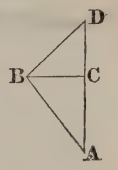
By Calculation.

mer diff lat 1042 miles	3·017868	as radius	10·000000
: rad	10·000000	: prop diff lat 745 miles	2·872156
: : diff long 1295	3·112270	: : sec course 51° 11′ .	10·202850
: tan course N 51° 11′ E	10·094402	: dist 1189	3·075006

2. A ship sails in the N W quarter 248 miles, till her departure is 135 miles, and her diff long 310 miles, required her course, the latitude left, and the latitude come to ?

By Construction.

Draw the meridian line A D, and at C in that line erect a perpendicular, on which take B C, equal to the departure 135 miles. From B, with the diff long 310 miles, cut A D in D; and from the same point B, with the distance 248, cut A D in A, and join B D, A B. Then B D will represent the diff long, A B the distance, ∠ A the course, A C the diff lat, and ∠ D B C the mid lat, or half the sum of the required latitudes. By measuring the different parts, we find A C 208 miles, ∠ A 33°, and ∠ D B C 64° 11′. Hence the course is N 33° W, and as half the diff lat added to the middle lat gives the greater, and subtracted leaves the less latitude, the lat left is 62° 27′, and the lat come to 65° 55′.



By Inspection.

In Table 2. with the dist 248 miles, and the dep 135 miles in their own columns, we find the course at the top of the page to be 33°, and the diff lat 208 miles; and with the diff long 310 miles in the distance column, and the dep. 135 miles in the lat column, the mid lat is found at the bottom of the table as a course, nearly 64°. Hence the latitudes are found as above.

By Gunter's Scale.

Extend from the dist 248 miles to the dep 135 miles, on the line of numbers that extent will reach from rad to the course 33° on the line of sines. Extend from the diff long 310 miles to the dep 135 miles, on the line of numbers, that extent will reach from rad to the comp of 64° 11′, the mid lat on the line of sines. Extend from rad to the comp of the course on the line of sines, that extent will reach from the distance to the diff lat, 208 miles, on the line of numbers.

By Calculation.

dist 248 miles.....	2·394452	rad	10·000000
: rad	10·000000	: dep	2·130334
: : dep 135 miles	2·130334	: : cot course.....	10·187759
: sin course 32° 59′ ..	9·735882	Diff lat 208 miles ...	2·318093

As diff long 310 miles	2·491362
: rad	10.000000
: : dep 135 miles	2·130334
: cos mid lat 64° 11′	9·638972

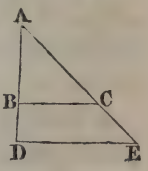
64° 11′ mid lat	60)208 miles diff lat
1 44 half diff lat	2)3° 28′
62 27 N lat left	1 44 half diff lat.
65 55 N lat in	

Note. *The preceding example cannot be solved by Mercator's sailing.*

3. If a ship sail from Cape Finisterre, lat 42° 54′ N, S E ¼ E, till her diff of longitude is 134 miles, required her distance and latitude in?

By Construction.

Draw the meridian line A D, and at D erect the perpendicular, D E, and make it equal to 134 miles, the diff long. Make the angle A E D equal to 3¾ points the complement of the course, and let E A meet A D in A, then A D measured on the scale of equal parts from which D E was taken, will be found about 121 miles, the mer diff lat. Now A D subtracted from the mer parts of the latitude of Cape Finisterre will leave 2734, the mer parts of 41° 25′, the latitude arrived at. Hence the proper diff lat is 89 miles. Make A B equal to 89 miles, and draw B C parallel to D E, then A C will be the distance, and equal to about 132 miles.



By Inspection.

Enter Table 1. with the course 4¼ points at the bottom of the table, and the diff long 134 miles, in the dep column, and corresponding to it in the lat column will be found 121·5, the mer diff lat. Find the lat in and diff lat as above, and enter the table with the course, and corresponding to 89 in the lat column will be found the dist, about 132·5 miles in its own column.

By Gunter's Scale.

Extend from rad to the complement of the course 3¾ points on the line of tan rum, that extent will reach from the diff long 134 miles on the line of numbers towards the left, to the mer diff lat 121 miles. Extend from rad to the complement of the course on the line of sines, and that extent will reach towards the right from 89 miles, the diff lat, to 131·5 miles, the distance.

By Calculation.

radius	10·000000
: diff long 134 miles	2·127105
:: cot course 4¼ points	9·957295
: mer diff lat 121·5 miles	2·084400

Latitude Cape Finisterre 42° 54′ N mer parts ... 2855
mer diff lat .. 121 S

lat in ..... 41 25 mer parts ... 2734
diff lat ..... 1 29 = 89 miles.

As radius ..... 10·000000
: proper diff lat 89 miles .... 1·949390
:: sec of course 4¼ points ... 10·172916
: dist 132·5 miles ..... 2·122306

Note. *The preceding example cannot be solved by middle latitude sailing.*

Examples for Exercise.

1. If a ship sail from Lisbon W S W ½ W 168 miles, required her latitude and longitude? Answer, lat 37° 54′ N, long 12° 33′ W.

2. If a ship sail from Cape Race S S E ¾ E 216 miles, required her latitude and longitude? Answer, 43° 35′ N, and long 50° 26′ W.

3. Required the course and distance from lat 41° 46′ S, long 10° 34′ E, to Rio Janeiro?
Answer, course N 67° 17′ W, dist 2933 miles.

4. A ship from the lat 40° 12′ N, long 18° 3′ W, is bound for England; after sailing N E b N ½ N 248 miles, required her course and distance to the Lizard? Answer, course N 48° 49′ E, dist 557 miles.

5. If a ship sail from lat 40° 5′ N, long 28° 14′ W, E N E ½ E till her difference of longitude is 320 miles, required her distance, latitude, and departure?
Answer, lat 41° 18′ N, dist 251·5 miles, and dep 240·6 miles.

6. A ship from Cape Horn sails in the south-west quarter, till she arrives in lat 60° 10′ S, having made 218 miles difference of longitude, required her course and distance?
Answer, course S 24° 34′ W, dist 277 miles.

7. A ship from the Cape of Good Hope sails N W b W till she arrives in lat 30° 4′ S, required her course and distance to St. Helena?
Answer, course N 47° 5′ W, and dist 1247 miles.

8. Required the course and distance from lat 53° 18′ N, long 0° 55′ E to the Naze? Answer, course N 36° 31′ E, and dist 348 miles.

9. If a ship leave Cape Clear, bearing N E ¾ N 16 miles, and sail S W ¾ S 150 miles, required her course and distance to St. Mary's, Azores? Answer, course S 37° 57′ W, and dist 931 miles.

10. A ship bound for Cork was met at sea by another, which had sailed from Cape Ortegal, N W b N 186 miles, required the ship's course and distance to Cork harbour?
Answer, course N 13° 18′ E, and dist 338 miles.

11. A ship from lat 40° 41′ N, long 16° 37′ W, sails in the N E quarter till she arrives in lat 43° 57′ N, and has made 248 miles departure, required her course, distance, and longitude in?

Answer, course N 51° 41′ E, dist 316 miles, and long in 11° W.

12. How far must a ship sail N E ½ E from lat 44° 12′ N, long 23° W, to reach the parallel of 47° N, and what, from that point, will be the bearing and distance of Ushant?

Answer, she must sail 265 miles, and her course and distance to Ushant will then be N 80° 32′ E, 535 miles.

TO FIND THE DIFFERENCE OF LONGITUDE MADE ON A COMPOUND COURSE.

Form a traverse table, and find the diff of latitude and departure, latitude arrived at, and course made good, as in traverse sailing. Take the middle latitude between the latitude left and the lat arrived at, and the meridional diff lat between the same two latitudes: then with the departure made by the traverse table, and the middle latitude, find the diff long by middle latitude sailing; or with the course made good by the traverse table, and the meridional diff of latitude, find the diff long by Mercator's sailing, and it will always be of the same name with the departure.

The above method will generally determine the diff long with sufficient exactness in such traverses as can be made in the course of a day; but, in strictness, the diff long ought to be computed for every separate course; and, when the traverse is performed in a high latitude, it may often be expedient to do so.

This may easily be done by finding the successive latitudes made at the end of every course, the middle latitude between that at the beginning and that at the end of each course, and the meridional diff lat between each pair of successive latitudes. Then, with the middle lat for each separate course, and the departure made on the same course, the diff long made on that course may be found by middle latitude sailing; or with each separate course, and the meridional diff lat made on it, the diff long may be found by Mercator's sailing.

If, then, the several diff longitudes thus found be entered in two columns, marked E and W, according as the course has been easterly or westerly, the difference between the sum of the numbers in these columns will be the whole difference of longitude made on the traverse, and of the same denomination with the greater sum.

Note 1. When the course is N or S no diff long will be made; and when it is due E or W the diff long must be found by parallel sailing.

Note 2. In practice, the diff long may in general be determined with

sufficient exactness by inspection, and the middle latitude method may be used in preference to Mercator's, when the course exceeds 5 points, or 56°.

Example.

A ship in lat 66° 14′ N, long 3° 12′ E, is bound for Archangel; after sailing N N E ½ E 46, N E ½ E 28, N ¾ W 52, N E b E ¼ E 57, and E S E 24 miles, required her course and distance to the North Cape?

TRAVERSE TABLE.

Courses.	Dist.	Diff Lat.		Dep.	
		N	S	E	W
N N E ½ E	46	40·6		21·7	
N E ½ E	28	17·8		21·6	
N ¾ W	52	51·4			7·6
N E b E ¼ E	57	29·3		48·9	
E S E	24		9·2	22·2	
Course.		139·1	9·2	114·4	7·6
N 39° ½ E	168	9·2		7·6	
		129·9		106·8	

Lat left	66° 14′ N	Mer parts	5358	Long left	3° 12′ E
diff lat	2 10 N			diff long	4 39 E
lat in	68 24 N	.....	5695	long in	7 51
2)	134 38	mer diff lat	337		
mid lat	67 19				

With the diff lat 129·9, and departure 106·8, the course is found in Table 2. to be about 39½°, and the distance 168 miles. With this course, and mer diff lat 337 in the latitude column, the diff long is found in the departure column to be about 278 miles.

Or with the middle lat 67° 19′ as a course, and the departure 106·8 in the lat column, the diff long is found in the distance column to be nearly 279 miles.

To find the diff long made on each course separately by middle latitude sailing.

	Successive Lat.	Mid Lat.	Departure.	Diff Long. E	Diff Long. W
Lat left	66° 14′				
at the end 1st Course.	66 55	66° 34′	21·7 E	54·6	
2d	67 13	67 4	21·6 E	54·4	
3d	68 04	67 38	7·6 W		20·0
4th	68 33	68 18	48·9 E	132·3	
5th	68 24	68 28	22·2 E	60·5	
Long left.....	3° 12′ E			301·8	
diff long	4 43 E			20·0	
long in	7 55 E			281·8	

With each middle latitude, and the corresponding departure extracted from the previously given traverse table, the diff long is found and entered in the column which is of the same name with the departure, and the difference between the change of long made towards the east, and that made towards the west is 281·8; the whole diff long made on the traverse, differing about 4 miles from that found from the diff lat and departure made on the whole traverse.

To find the diff long made on each course separately by Mercator's sailing.

Courses.	Successive Lat.	Mer Parts.	Mer Diff Lat.	Diff Long. E	Diff Long. W
	66° 14′	5358			
N N E ½ E	66 55	5461	103	55·1	
N E ½ E	67 13	5507	46	56·1	
N ¾ W	68 4	5642	135		20
N E b E ¼ E	68 33	5720	78	130·1	
E S E	68 24	5695	25	60·4	
Long left.....	3° 12′ E			301·7	
diff long	4 42 E			20	
long in	7 54 E			281·7	

With each course, and the mer diff lat made on that course, the diff long is found and entered in the columns, marked E or W, according as the course has been easterly or westerly, and the difference between the sum of the numbers in the E and W columns is 281·7, the diff long, almost identical with that found by middle latitude sailing.

Hence the lat in is 68° 24′, and the longitude computed from the result of the whole traverse is 7° 51′; but by computing the diff long for each course separately, the long is 7° 54′ East.

To find the course and distance from the ship to the North Cape.

Ship's place lat	68°	24′	N	Mer parts	5695	Long 7° 54′ E	
N Cape.....	71	10	N	.....	6177	26 1 E	
Diff lat 166 =	2	46	N	Mer diff lat	482	Diff long 18 7 =	1087
2)	139	34					
Mean mid lat.	69	47					
Cor. (tab. p. 174)		3					
True mid lat.	69	50					

By Calculation.

By Middle Latitude Sailing.

Diff lat 166	2·220108	Sin course	9·961067
: diff long .. 1087 ..	3·036230	: cos mid lat	9·537507
: : cos mid lat 69° 50′.	9·537507	: : diff long	3·036230
	12·573737		12·573737
Course 66° 6′ tan ..	10·353629	: dist 409·9	2·612670

By Mercator's Sailing.

Mer diff lat 482	2·683047	radius	10·000000
: rad.....	10·000000	: diff lat 166.....	2·220108
: : diff long 1087....	3·036230	: : sec course 66° 5′ ..	10·391823
: tan course 66° 5′ ..	10·353183	: dist 409·5	2·612216

Hence the course to the North Cape is about N 66° E, 410 miles.

Examples for Exercise.

1. If a ship sail from the Naze, W N W 24, N W ½ W 16, S S W 31, S ¼ E 12 and S W ¾ S 20 miles, required her latitude and longitude?

Answer, course S 57° 5′ W, lat 57° 20′ N, and long 5° 15′ E.

2. If a ship sail from Funchal S 59, W 46, S W ½ W 15, and S ¼ W 24 miles, required her latitude and longitude?

Answer, course S 32° 27′ W, dist 109·6 miles, lat 31° 5′ N, and long 18° 7′ W.

3. If a ship sail from the Cape of Good Hope N W 25, N ½ W 21, N N E ¼ E 35, N W ¾ W 40, and N b E 18 miles, required her latitude and longitude? Answer, lat 32° 32′ S, and long 17° 52′ E.

4. If a ship sail from Fort Royal, in the Island of Grenada, for Kingston, in Jamaica, N W 46, N N W ¾ W 50, N W b W 70, and W ½ N 21 miles, required her latitude and longitude, and distance from her destination?

Answer, lat 13° 59′ N, long 64° 9′ W, course N 71° 38′ W, and dist 765·5 miles.

5. A ship from Toulon sails S S W 48, S b E 34, S W ¼ W 26, and E 17 miles, required her course and distance to Port Mahon?

Answer, lat in 41° 32′ N, long 5° 37′ E, course S 30° 38′ W, and dist 116·2 miles.

6. If a ship sail from the Butt of Lewis W S W 26, S W ½ W 42, S S W 13, W b N 29, W 12, S ¾ E 18, S E ½ S 10, and W b S 15 miles, required her latitude and longitude, and course and distance to the Peak of Pico?

Answer, lat 57° 18′ N, long 9° 33′ W, course S 33° 52′ W, dist 1349 miles.

7. If a ship take her departure from Cape Race, bearing N W 18 miles, and sail S E 32, S E ½ S 16, S E b E 34, E ¾ N 40, and E 16 miles, required her place, and the bearing and distance of Corvo, one of the Western Islands?

Answer, lat 45° 39′ N, long 49° 56′ W, course S 66° 44′ E, dist 906 miles.

8. If a ship sail from Cape Farewell, in Greenland, for Oporto, E 86, E b S 120, and S 39 miles, required her course and distance to her destined port?

Answer, lat in 58° 43′ N, long 41° 12′ W, course S 49° 37′ E, and dist 1627 miles.

9. A ship is by observation in lat 24° 14′ N, long 48° 20′ W, and sails W S W 24, S W ¾ W 90, S ½ W 24, and W by N 41 miles, required her course and distance to Antigua?

Answer, lat in 22° 55′ N, long 50° 50′ W, course to port S 60° 39′ W, and dist 716 miles.

10. If a ship from Heligoland sail N W b N 26, N W ¾ N 34, N b E 12, W ½ S 42, and N N E 38 miles, required her place, and course and distance to Aberdeen?

Answer, lat in 55° 44′ N, long 6° 9′ E, course to port N 72° 51′ W, and dist 288·1 miles.

11. If a ship from Cape Horn sail S E ½ S 46, S E b E 72, E S E 90, S ¾ W 51, and S S W ½ W 61 miles, required her course and distance to Cape Smith, New Shetland, finding the difference of longitude upon each course?

Answer, lat in 59° 32′ S, long 63° 14′ W, course S 3° 52′ W, and dist 200·5 miles.

12. A ship from lat 6° 28′ N, long 63° 27′ E, bound for Bombay, sails N N E 16, N ½ W 43, N E ¼ N 70, N E b N 43, and N b E ¾ E

14 miles, required her latitude and longitude, the course to be steered, and the distance to be sailed to arrive at her port?

Answer, lat 9° 6′ N, long 64° 45′ E, course to port N 39° 2′ E, and dist 756 miles.

13. By observation, a ship is found to be in lat 41° 50′ S, long 68° 14′ E; she sails N E 140, and E ½ S 73 miles, required her place, and course and distance to the Island of St. Paul?

Answer, lat 40° 18′ S, long 72° 2′ E, course N 68° 31′ E, and dist 262·0 miles.

ON CHARTS.

A CHART is a representation of the whole or part of the surface of the globe, exhibiting particularly every thing calculated to facilitate the business of navigation. There are two kinds of charts in use among seamen, the *plane chart* and the *Mercator's chart*. In plane charts, in which it is attempted to exhibit the latitudes and longitudes of places, the meridians are drawn parallel to each other, the degrees of the parallels of latitude, as well as those of the meridians, being represented as equal to the degrees of the equator. The longitudes and relative positions of different places must therefore on such charts be exhibited very erroneously; and, in fact, charts of this kind can scarcely be considered as of any practical utility.

But abstracting from the consideration of *latitude* and *longitude*, there will be no material error in representing a small portion of the earth's surface as if it were actually a plane; and coasting charts are generally constructed on that supposition. In plane coasting charts neither latitude nor longitude is considered, and places are represented according to their relative distances and angular positions; and as these charts in general comprehend but a small extent of coast, they can be drawn on a large scale, and, in consequence, many things can be inserted in them which it is impracticable to introduce in a more general chart.

Plane charts, which show in an approximate way the latitudes and longitudes, bearings and distances, of places comprehended within small portions of the earth's surface, may be constructed thus:—

Draw a line at the bottom of the paper to represent the parallel at which it is proposed the chart should begin, erect a perpendicular by the side of the page, and set off upon it as many degrees of latitude as it is intended the chart should extend to, and of such a magnitude as may be thought proper, subdividing the degrees into such smaller portions as the size will admit; and at convenient intervals draw lines parallel to the bottom one to represent the parallels of latitude. Then to determine the proper length of a degree on the parallels, take the

latitude of the middle parallel on the chart as a course, in Table 2, and corresponding to 60 in the distance column, will be found the length of a degree on the parallel, in the latitude column; which being taken from the previously divided meridian, and laid off on the bottom parallel, will divide it into degrees of longitude nearly. From such points of the divided parallel as may be thought proper (say at every degree) meridians may be drawn parallel to the divided one, and the degrees of longitude which the chart is intended to embrace may be marked on the parallels at the bottom and top of the page; and the degrees of latitude on each side of the middle latitude, used in computing the degrees of the parallel, may be marked at their proper places. Then, a compass being drawn in any convenient situation on the chart, and the different places included in it marked according to their latitudes and longitudes, the coasts, &c. may be traced out and shaded, and the chart will be completed.

Such charts are of limited use to seamen, however, when compared with the Mercator's chart, the construction of which may be thus explained.

Having drawn at the bottom of the paper a line to represent the lowest parallel on the chart, and divided and subdivided it as may be thought convenient for degrees, &c., of longitude, let this line be considered as a *general line of measures*, and draw perpendiculars at the extremities of it to represent the extreme meridians. Then to obtain the proper length of the degrees in the different parts of the meridian proceed as follows.

Take from Table 3, the meridional parts for the latitude at which it is proposed the chart should commence, and also for each successive degree of latitude intended to be contained in it. Then find the meridional difference of latitude between the latitude of the lowest parallel, and every other one intended to be contained in the chart, and dividing them by 60, for degrees, &c., take the quotients from the bottom line, or the line of measures, and apply them from the bottom on the extreme meridians, and the degrees of latitude will thus be determined; and they may be farther subdivided in a manner similar to the degrees of longitude. The meridians and parallels of latitude being then drawn at such intervals as may be judged convenient, the situation of every remarkable place, rock, island, shoal, &c., comprised within the space represented by the chart, may be laid down from its known latitude and longitude; and a compass (or more than one, if the chart be large) being inserted in any convenient situation, to determine the relative bearings of the different points on the chart, the coasts, sands, rocks, &c., may be drawn and shaded, and the chart will be completed.

USE OF MERCATOR'S CHART.

To find the latitude and longitude of any place on the Chart.

Take the perpendicular distance of the given place from any convenient parallel, and from the point where that parallel cuts the graduated meridian, apply the distance upon the meridian in the same direction that the place lies with respect to the parallel, and the point to which the distance reaches will be the latitude of the place.

In the same way, if the perpendicular distance of a place from any meridian be taken and applied from the place where that meridian cuts the divided parallel, the longitude of the place will be determined.

From the latitude and longitude of a place to find its situation on the Chart.

Lay the edge of a scale over the parallel of the given latitude; measure on one of the graduated parallels the distance of any convenient meridian from the given longitude, and apply this distance along the edge of the scale from the place where the meridian measured from cuts the scale, in the same direction that the longitude lies from the meridian; and the point to which the distance reaches will be the required situation of the place.

To find the course between two places on the Chart.

Lay the edge of a scale over both the places, and applying a parallel ruler to the edge of it, move the two parts of the ruler in succession till the edge of one of them passes through the centre of a compass, and that edge will, on the compass, indicate the course.

Or draw a line in pencil along the edge of the scale, cutting any meridian, and the angle included between the line and the meridian will be the course.

Or, lastly, having laid the scale over the places as before, place one foot of a pair of compasses in the centre of any convenient compass on the chart, and with the other take the nearest distance to the edge of the scale. Then carry both points of the compasses forward, keeping one of them by the edge of the scale, and the imaginary line which joins them perpendicular to the edge; and the line which the other point describes from the centre of the compass will indicate the course.

To find the distance between two places on the Chart.

If the places are in the same longitude, find the latitude of each, and

if their latitudes are of the same denomination, take their *difference*; otherwise, their *sum* for the distance of the places.

If they are in the same latitude, or the same parallel, take half their distance, and apply it on the graduated meridian on both sides of the parallel on which the places are situated, and the degrees of the meridian intercepted between the two points to which the distance reaches will be the distance of the two places, *nearly*.

But if the places differ both in latitude and longitude, lay a scale over them both, and taking half their distance, apply it both upwards and downwards on the graduated meridian from the middle parallel between the two places, and the degrees of the meridian intercepted between the points to which the distance reaches will be the distance of the places *nearly*.

If half the distance be too great to be conveniently measured at once, one-fourth, or one-eighth of it may be taken, and applied upwards and downwards from the middle parallel as before, and the intercepted degrees of the meridian will be one-half, or one-fourth of the required distance *nearly*.

The distance may be found by the following method, which is exact in principle, and is in fact only an abridged solution of the question by construction, on the principles of Mercator's sailing.

Find the diff lat between the two places, and take it in the compasses from the graduated parallel. Then having laid a scale over the two places, slide one foot of the compasses along its edge till the other, in sweeping, just touches a parallel of latitude; and the distance from the point where that parallel cuts the scale to the point of the compasses by the edge of the scale, applied to the graduated parallel, will shew the distance of the two places. But this method should not be used when the course is very large.

From the course and the distance which a ship has run from a known place, to determine her situation on the Chart.

Lay the edge of a scale over the given place in the direction of the ship's course, and take the distance, reduced to degrees, &c., from that part of the graduated meridian opposite the place on which the ship has been sailing, and this distance, applied from the given place along the edge of the scale, will determine the situation of the ship.

The method of using a plane chart, on which the latitude and longitude are marked, is the same as the method of using a Mercator's one, except that the distance between places is in all cases determined by applying their distance on the chart to the graduated *meridian*.

But in coasting charts, where latitude and longitude are not in general noticed, the distances of places are measured on a scale adapted to the chart, and inserted in some part of it; and the mag-

netic bearings and courses between places are determined by their situations with respect to the points of a compass drawn also in some convenient part of the chart, and adapted to the *magnetic*, not the *true* meridian.

ON A SEA JOURNAL.

A JOURNAL is a register of occurrences that take place on board a ship, either in harbour or during a voyage, and it ought to contain a particular detail of everything relative to the navigation of the ship, as the courses, winds, currents, &c., that her situation may be known at any instant at which it may be required.

On commencing a voyage, the true course to the first place which is expected to be seen is either taken from a chart or computed; and thence, from the variation, the compass or steering course is found; and the ship is kept as near that course as the wind and other circumstances will admit. When the ship leaves the land, the bearing of some known place is taken by the compass, and its distance is in general estimated by the eye, which seamen soon acquire considerable skill in doing. This is called *taking the departure*. But the distance may be otherwise determined by taking the bearing of an object at two different times, carefully noting the course and distance run in the interval. For the sine of the change in the object's bearing, is to the distance run by the ship in the interval, as the sine of the angle included between the ship's course, and the bearing of the object at the first observation, is to its distance at the second observation.

But whether the distance of the place from which the departure is taken, is estimated or computed, the opposite point to that on which it bears is considered as the first course, and its distance as the first distance sailed from the place; and the other courses and distances made during the day, being determined by the compass and the log, they are severally written in chalk, on a painted black board, called the *log-board*, of which the general form will be found below; and afterwards copied into a book, similarly ruled, called the *log-book*. The courses are either corrected for leeway before they are put down on the *log-board*, or the leeway is marked in the proper column opposite the course to which it belongs. The setting and drift of currents, and the estimated effect of the swell of the sea, are also inserted in the column of remarks; and this column, besides, must contain an account of every occurrence deemed of importance.

Then the several courses in the log-book being corrected, as in the

preceding problems, for leeway and variation, and the distances on each course summed up and entered in a traverse table, care being taken to introduce the effect of currents and the swell of the sea, when any exist, as separate courses and distances, the latitude and longitude arrived at are determined by the methods which have already been explained, under the different heads of Practical Navigation; but in general the whole of the computations may be performed with sufficient exactness by *inspection*.

The computation of the ship's place from the reckoning is always made at noon, and the operation is called working a *day's work*. An abstract of the result is inserted in the log-book, containing the true course and distance which the ship on the whole has made during the day; the latitude and longitude as deduced from the reckoning, with those also which are obtained from observations; and the bearing and distance of the port, or of the nearest land that lies in the ship's way.

When the variation of the compass is given in degrees, it will be found convenient first to correct the courses in the traverse table for leeway only, and, with these courses and distances, to find the difference of latitude and departure, and thence the *compass course* and the distance made during the day. This resulting course being then corrected for variation, with it and the distance already found, the *true* difference of latitude and departure may be readily obtained; and the calculation for the difference of longitude may then be made in the usual manner.

In hard-blowing weather, with a contrary wind and a high sea, it is impossible to gain any advantage by sailing, and the object is then to avoid, as much as possible, being driven back. To effect this object, it is usual to lie-to under no more sail than is necessary to prevent the violent rolling which the ship would otherwise acquire. The tiller being put over to leeward brings the ship's head round towards the wind, which then having little power on her sails, she loses her way through the water, and the directive power of the rudder consequently ceases; her head falls off from the wind, the sail which she has set fills again, and gives her fresh way through the water, which acting on the rudder brings her head about to the wind, and she thus comes up and falls off alternately. In such cases the middle point between those on which she comes up and falls off is taken as her apparent course, and the leeway and variation being allowed from that point, the result is entered as a course in the traverse table, with the estimated drift of the ship through the water as a distance.

But notwithstanding all the care that can be taken in keeping a sea reckoning, the place of the ship as deduced from it must always be considered as only *approximately* determined. It is often extremely difficult to arrive at any considerable certainty respecting the precise course and distance which a ship has actually made. Different rates

of sailing between the times of heaving the log, want of care in steering, and sometimes also the great difficulty in steering steadily; sudden squalls, incorrect allowances for leeway and variation, and many other circumstances, conspire to render the ship's place, as deduced from the common reckoning, very uncertain. No opportunity ought therefore to be lost to determine her place by celestial observations; and the sea-reckoning should chiefly be considered as a means of estimating her situation *nearly* in her interval between such observations.

The log is dated according to the civil reckoning of time, and the place of the ship therefore, computed at noon, is for the middle of the civil day; the courses and distances in the afternoon or P. M. of the preceding day, being connected with those made in the morning, or A. M. of the current day, in computing the change of her place from the last noon.

When the place of the ship has been determined by observation, her place by the reckoning ought to be disregarded, and the future reckoning should be carried forward from her place found by observation, till other observations give a new point of reference. But some mariners keep a separate account of the ship's place, by the reckoning and by observation, during the whole voyage; which, as they conceive, enables them to judge of the total effect of currents and other generally operating causes of error on the reckoning.

The explanatory remarks on the method of working the first two days' works in the following journal, will enable the student to understand how to proceed in any case. The *results* only of the last four days' works are given, the computations being left as an exercise.

A more extended journal might have been given, but the author has found it more advantageous, in teaching this branch of navigation, to propose to the student, after he has acquired a knowledge of the method of working a day's work, to undertake the fancied charge of the navigation of a ship on a proposed voyage; the teacher giving the winds, and the student, under his direction, finding what in the given circumstances will be the most advantageous courses to steer. Then such distances, leeway, &c., being given, as the teacher with a due regard to the wind, &c., judges proper, the student proceeds to make the proper corrections on the different courses, and to determine, as in actual sea practice, the situation of the ship.

When observations are obtained for the latitude only, and the latitude by observation differs from that by account, some persons apply a conjectural correction to the difference of longitude for the error in the reckoning, which the observed latitude indicates. Such corrections however ought never to be applied, unless the real cause of the mistake should be discovered; but the longitude as well as the latitude

should be carried forward by the reckoning from the last observation, till another can be obtained.

The occurrences of the afternoon or P. M. are written on the lower half of each page, and those of the forenoon or A. M on the upper half of the following page. Each page therefore shows what has been done during the *civil day*, and the result of the day's work in the middle of the page between A. M. and P. M. shows the situation, &c., of the ship at noon.

Extract from a Journal of a Voyage from St. Michael's towards England.

H.	K.	F.	Courses.	Winds.	Lee-way.	Remarks. Sunday, Sept. 11th, 1831.
						P. M.
1				W		Moderate and clear weather. Under courses, single reefed topsails, fore top gallant sails, jib, spanker and larboard studding sails.
2						
3				N N W		At 3 P. M. the eastern end of St. Michael's, which is in lat 37° 48′ N, long 25° 13′ W, bore W S W, dist about 6 leagues, from which I take my departure. In studding sails.
4	5	8	E N E ½ E			Ditto weather.
5	5	7		N		Fresh breezes and cloudy weather. In top gallant sails.
6	5	4				Ditto weather.
7	4	2	E b N	N b E	½	In second reef topsails hauled down the jib, and set fore topmast staysail.
8	4	1				Strong breezes and hazy weather; brailed up the spanker and set the mizen staysail.
9	3	0	E b S	N E b N	2	
10	3	0				In third reef topsail, and set the try-sail.
11	2	8				
mid-night	2	6				Ditto weather.

H.	K.	F.	Courses.	Winds.	Lee-way.	Remarks. Monday, September 12, 1831.
						A. M.
1	3	4	E S E	N E	3½	Fresh gales and hazy weather. Close reefed the topsails; a heavy swell from the N N E; estimated drift 18 miles.
2	3	6				
3	3	9			3	More moderate.
4	4	2				Out fourth reef of the topsails.
5	4	3	N N E	E b S	2¼	Tacked, strong breezes, and cloudy weather.
6	4	0			2	Out third reef topsails, set the jib and spanker.
7	4	5				Set top gallant sails. Fresh breezes and cloudy weather.
8	5	0			1½	
9	4	7				Out second reef topsails.
10	4	2			1	Moderate and clear weather. Lat. by doub. alts. at 11 A.M. ... 38° 15′N Diff lat. till noon 5 N 38 20 N lat. at noon.
11	4	8			½	A ship in the S E quarter steering under all sail to the S W.
noon	4	8				Ditto weather.
						Variation per Amp. 1¾ Points W.

Course.	Dist.	Lat. Acct.	Lat. Obs.	Long Account.	Long Observ.	Bearing and Dist. at noon.
N 58° E	mls. 57	38° 19′ N	38° 20′ N	24° 11′ W		Lizard N 49½° E, dist. 1074 mls.

						P. M.
1	4	6	N N E	East	1¼	Moderate and clear weather.
2	5	0				Out first reef topsails, set the royals and flying jib.
3	5	3	N b E¾ E	E ¼ N	½	Light breezes and clear weather.
4	5	6				Ditto weather. A swell from the E from 4 P.M. till 8 A.M. for which I allow a drift of 24 miles.
5	6	0				
6	6	1				In royals and flying jib.
7	5	8	E S E	N E	1	Tacked.
8	5	7				
9	5	0			½	Moderate and clear weather.
10	5	3				
11	5	8			0	
mid-night	6	2				Ditto weather.

H.	K.	F.	Courses.	Winds.	Lee-way.	Remarks. Tuesday, September 13, 1831.
						A.M.
1	5	9	E S E	N E	1¼	Moderate and clear weather.
2	5	7				
3	5	3			1	Fresh breezes, in top gallant sails.
4	5	4				
5	5	0				
6	5	0	E N E	N	1½	In first reef topsails.
7	4	8				Strong breezes and cloudy.
8	4	3				In second reef topsails.
9	3	9			2	Long. per chronometer, at 8 A.M. ..... 23° 2′ W Diff. long. made till noon ... 17 E Long. at noon ..... 22 45 W
10	3	4				Flying clouds with light showers.
11	3	3			2½	Fresh gales and squally; down jib and in spanker.
noon	3	5				Lat. at noon by mer. alt. 38° 46′ N. Variation 20° W per azimuth.

Course.	Dist.	Lat. Acct.	Lat. Obs.	Long. Account.	Long. Observ.	Bearing and Dist. at noon.
N 69° E	mls. 63	38° 43′ N	38° 46′ N	22° 56′ W	22°45′ W Chron.	Lizard N 48½°E, dist. 1013 m. Ushant N 53 E, ... 968

						P.M.
1	3	0	E N E ¼ E	N ¼ E	3	Fresh gales and stormy weather, with showers of rain.
2	3	1				In third reef topsails.
3	2	8				
4	2	7	E N E	N	4	Close reefed topsails and set the trysail.
5	2	6				
6	2	8				
7	2	4				Handed mizen topsail.
8	2	3			4½	Handed fore topsail.
9	1	8				Sent down top gallant yards.
10	1	7	E b N	N b E	6	Hauled the mainsail up, and set the main staysail; strong gales.
11	1	8				Struck top gallant masts.
mid-night	1	8			6½	Reefed the courses and set them, and hauled down the main staysail.

H.	K.	F.	Courses.	Winds.	Lee-way.	Remarks. Wednesday, September 14, 1831.
						A. M.
1	1	4	E	N N E	7	Strong gales and squally weather. Hauled the mainsail up, and handed it, and set the main staysail
2	1	3				
3						
4			Up E b S Off S b E	N ½ E	7½	Heavy gales and rain. Hauled the foresail up, set the fore staysail, and reefed the trysail. Ship labouring. Hauled down the fore and main staysail, got the jibboom in.
5						
6						
7						
8			Up W Off S W b S		7½	Ditto weather. Ship under reefed trysail.
9						Gale increasing, with a heavy sea. Handed the main topsail.
10			Up E ½ S		8	
11			Off S			Heavy sea. Took in trysail, and lay to under bare poles. Allow 1 mile per hour for drift while lying to.
noon						Variation, 2 Points W.

Course.	Dist.	Lat. Acct.	Lat. Obs.	Long. Account.	Long. Observ.	Bearing and Dist. at noon.
S 64° E	mls. 31	38° 33′ N		22° 10′ W		Lizard N 46¾° E, dist. 999 m. Ushant N 51¼ E, .. 951

						P. M.
1			Up N W Off W S W	N E	8	Heavy gales, and violent squalls.
2			Up N W Off W b S		7	Gale abating; drift 1 mile per hour.
3	1	5			6	More moderate; set close reefed main topsail, reefed foresail, and main staysail.
4	2	2				Wore ship.
5	2	0	E	N N E	5	Wore again, and set close reefed fore topsail.
6	3	1	N W		4	
7	3	4	N N W	N E	4	
8	3	6			3	
9	3	4				
10	3	6	N	E N E	2	
11	4	0				
mid-night	4	1			1½	Fresh gales and cloudy weather. Wore ship.

H.	K.	F.	Courses.	Winds.	Lee-way.	Remarks. Thursday, September 15, 1831.
						A. M.
1	4	7	N E b E	N b W	1	Fresh gales and cloudy.
2	5	4				
3	5	0	E b N	E b N	½	Fresh breezes and cloudy weather, out 4th and 3d reef topsails.
4	5	3				Clear at intervals. Tacked.
5	4	6	NbW½W	N E ½ E	¾	Out reef foresail; set whole mainsails.
6	4	2				
7	4	9				Up top gallant mast and yards; out 2d reef topsails; set top gallant sails, jib and spanker.
8	5	3	NNE¼N	E	0	Long. by chron. at 8½ h. A.M. 22° 40′ W Diff. long. till noon..... 10 E Long. by chron. at noon... 22 30 W
9	5	7				
10	6	2				Lat. at noon by ⊙'s mer. alt. 39° 32′ N
11	6	5	ENE½N	S E	0	Moderate and pleasant weather; a ship on our larboard quarter on the starboard tack.
noon	6	3				Variation by azimuth 23° W.

Course.	Dist.	Lat. Acc.	Lat. Obs.	Long. Account.	Long. Observ.	Bearing and Dist. at Noon.
N 8 ½° W	51	39° 23′ N	39° 32′ N	22° 20′ W	22° 30′ W Chron.	Scilly N 48° E, 928 miles. Ushant N 54½ E, 923

						P. M.
1	6	8	N N E	E ½ S	0	Moderate and clear weather.
2	5	7				
3	5	5				
4	4	3	E N E	S E	1	Set royals, fore topmast and fore top-gallant studding-sails,
5	4	4				
6	5	2				
7	5	4		S b W	0	
8	6	2		S W		Ditto weather.
9	7	3		W b N		Up mainsail and squared the yards; in studding sails and royals.
10	7	5				
11	6	4		N W		
mid-night	6	8		N	¼	Ditto weather.

H.	K.	F.	Courses.	Winds.	Lee-way.	Remarks. Friday, September 16, 1831.
						A.M.
1	4	3	E N E	N	0	Moderate weather; braced up and set the mainsail.
2	4	0	E S E	N E	¼	
3	4	6	E N E	N	0	Ditto weather.
4	4	2			½	Tacked. Fresh breezes and pleasant weather.
5	3	7	N	E N E	1¾	
6	4	0	N b E	E b N	1½	Tacked.
7	4	6	E S E ½ S	N E ½ E	0	
8	4	0			¼	Tacked.
9	5	6	N b E	E ½ N	0	Spoke a vessel from Lisbon to Halifax under all sail, out 5 days.
10	6	2	N N E	E ½ S		
11	6	5		E ¾ S		A swell from E, allow 10 miles for it.
noon	5	8		E		Lat. by ☉'s mer. alt. 40° 43′ N.
						Variation 2¼ points west.

Course.	Dist.	Lat. Acct.	Lat. Obs.	Long. Account.	Long. Observ.	Bearing and Dist. at noon.
N 22½° E	101·3	41° 5′ N	40° 43′ N	21° 39′ W	21° 27′ W Lunar	Scilly N 49¼° E, 843 miles. Ushant N 56⅓ E, 839.

						P.M.
1	6	3	E	N N E	0	Moderate and clear weather, set royals.
2	6	7				
3	7	3	E b N	N		Long. per ☉ and ☽, 21° 4′ W, at 3 P. M., whence long. last noon 21° 27′ W. Set topmast studding-sails. Fresh breezes and clear.
4	7	4				
5	6	7				In fore topmast, and top gallant studding-sails and royals. In first reef topsails.
6	6	2				
7	6	4				
8	5	8	E b S	N E b N	¼	In top gallant-sails, and second reef topsails.
9	5	7				
10	5	5				Tacked.
11	5	0	N N E	E	½	
mid-night	5	0				Ditto weather.

H.	K.	F.	Courses.	Winds.	Lee-way.	Remarks. Saturday, September 17, 1831.
						A. M.
1	4	8	N N E	E	½	Fresh breezes and cloudy.
2	4	9			¾	
3	5	1				
4	4	1	N N E ½ E	E ½ S	1½	
5	4	0				Out second reef topsails, moderate and fair.
6	4	6				
7	5	2	N E b N	E b S	¼	At 7 A. M. spoke H. M. S. Warspite, out 4 days from Plymouth—long. by her chron. 20° 27′ W, agreeing very well with our acct.
8	5	1				
9	5	6	E N E	S E	0	Long. by chron. at 9 A. M. .... 20° 22′ W Diff. long. till noon..... 19 E Long. by chron. at noon ... 20 3 W
10	6	3				
11	6	2	E b N	S S E		Lat. by double alt. at 11 A. M. 42° 14′ N Diff. lat. till noon..... 4 N Lat. at noon ..... 42 18 N
noon	6	7				Ditto weather. Variation 2½ points W.

Course.	Dist.	Lat. Acct.	Lat. Obs.	Long. Account.	Long. Observ.	Bearing and Dist. at noon.
N 33½° E	115	42° 19′ N	42° 18′ N	20° 2′ W	20° 3′ W Chron.	Scilly N 51½° E, 731 miles. Ushant N 59½ E, 731

It may be observed, in the first place, on the preceding days' works, that as the variation is westerly, it must be allowed to the left of the compass courses; and therefore when the ship makes leeway on the larboard tack, the difference between the leeway and variation is the correction to be applied to the course, to the *left* if the variation is *greater*, but to the *right* if the leeway is *greater*. When the ship makes leeway on the starboard tack, the allowance for it, as well as that for variation being to the left, their sum will be the correction to be applied to the compass course; and when no leeway is made, the only correction is for the variation. Now E N E, the opposite point to the bearing of the land, is the first course; and this and the drift being corrected for variation, and the other courses for variation and leeway (when there is any), and the distances on each added up, we have the following

TRAVERSE TABLE.

Courses.	Dist.	Diff. Lat. N.	Diff. Lat. S.	Dep. E.	Dep. W.
N E ¼ E	18	12·1		13.3	
N E ¾ E	16·9	10·1		13·6	
N E b E ¾ E	8·3	3·5		7·5	
E S E ¾ E	11·4		2·8	11·1	
S E ¼ E	7·0		4·7	5·2	
S E ¾ E	8·1		4·8	6·5	
N N W	4·3	4·0			1·6
N b W ¾ W	8·5	8·0			2·9
N b W ¼ W	9·7	9·4			2·4
N ¾ W	4·2	4·2			·6
N ¼ W	9·6	9·6			·5
S ¼ W	18		18·0		·9
		60·9	30·3	57·2	8·9
		30·3		8·9	
		30·6N		48·3E	

Lat left 37° 48′ N Mer pts 2453 Lon obs 25° 13′W
Diff lat 31 N Diff lon 1 2 E

Lat acct 38 19 N Mer pts 2492 Lon acct 24 11 W

2)76 7 M diff lat 39

Mid lat 38 3

See at p. 181 the method of finding the diff long by inspection.

From 11 A. M. till noon the ship's true course is N ¼ W, nearly 5 miles; whence the diff lat is also nearly 5 miles; which, added to the latitude by double altitudes at 11 A. M, gives 38° 20′ N for the latitude by observation at noon. With this latitude and the long by account, the bearing and distance of the Lizard are found to be N 49½° E 1074 miles.

The courses for the second day's work being first corrected for leeway only, as the variation is given in degrees, we have the following

TRAVERSE TABLE.

Courses.	Dist.	Diff. Lat. N.	Diff. Lat. S.	Dep. E.	Dep. W.
N ¾ E	9·6	9·5		1·4	
N b E ¼ E	23·0	22·3		5·6	
S E b E	11·5		6·4	9·6	
S E b E ½ E	10·3		4·8	9·1	
E S E	12·0		4·6	11·1	
S E ¾ E	11·6		6·9	9·3	
S E b E	15·7		8·7	13·0	
E ½ N	14·1	1·4		14·0	
East	7·3			7·3	
E ½ S	6·8		·7	6·8	
W (swell.)	24·0				24
		33·2	32·1	87·2	24
Course made per compass N 89° E		32·1		24·0	
Dist. 63 miles.		1·1N		63·2E	

Compass course N 89° E
Variation..... 20 W
True course... N 69 E, distance 63 miles.

With this course and dist 63 miles, found from the Traverse Table, the diff lat and departure are found to be 22·8 N and 58·8 E.

Lat left..38° 20′ N Long ....24° 11′ W
Diff lat.. 23 N Diff long. 1 15 E

Lat acct..38 43 N Long acct. 22 56 W

2) 77 3

Mid lat.. 38 31

The departure made, from 9 A. M. till noon, is nearly 14 miles, with which, and the mid latitude, about 38½°, the diff long is found to be 17 miles; which, taken from 23° 2′, the long by chron. at 9 A. M., gives 22° 45′ for the long by chron. at noon.

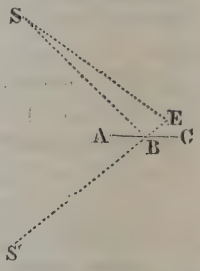
The remaining days' works are left as exercises.

ON THE QUADRANT AND OTHER REFLECTING INSTRUMENTS FOR MEASURING ANGLES.

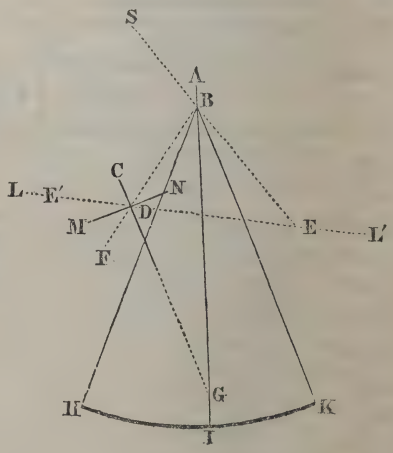
The quadrant, sextant, and reflecting circle, are in principle the same instrument, and the following is an explanation of the principle on which they are constructed.

Let A B C be a section of a reflecting surface, F B a ray of light falling upon it, and reflected again in the direction B E, and B D a perpendicular at the point of impact; then it is a well-known optical fact, that the angles F B C and E B A are equal, and that F B, D B, and E B are in the same plane.

Again, if A C were a reflecting surface, and a ray of light, S B, from any celestial object S, were reflected to an eye at E, the image of the object would appear at S′ on the other side of the plane, the angles S B A and A B S, as well as E B C, being equal; and if E B bear no sensible proportion to the distance of S, the angles S E S′ and S B S′ may be considered as equal; for their difference, B S E, will be of no sensible magnitude.



These principles being premised, let the quadrant or sextant be represented by B H K, a sector of a circle, having a revolving radius B I, which carries with it round the centre, a mirror A B, whose plane is perpendicular to that of the sector; and, for the sake of simplicity, let us suppose that B I is in the plane of the mirror. Let C D be another mirror which is parallel to A B when B I coincides with B K; and let A B and C D, the planes of the mirrors, meet when produced in G. Let S be a celestial object, and S B, B D, D E L′, the course of a ray of light proceeding from it, and reflected from the mirrors A B and C D in succession to an eye at E, where D E meets S B produced, and conceive B D to be produced to F. Then at E the object will appear at S, and its image at D, and the angle B E D will be the apparent distance of the object



from its reflected image; and whether the eye be at E, or at any point in the line D L′, the angular distance of S and its reflected image at D will be the same, if the distance of the eye from E be evanescent with respect to the distance of S. Now the angle S B A being equal to the angle D B G, by the above-mentioned property of reflection, and equal also to the vertical angle E B G, the angle D B E is bisected by B G; and B D C being, for a like reason, equal to each of the angles F D G and E D G, the angle E D F is bisected by D G, hence (Geom., Theo. 26.) the angle B G D, or the alternate angle G B K, which is measured by I K, is equal to half the angle B E D, the angular distance of the object from its reflected image.

In the quadrant, sextant, &c. the half degrees on the arc H K are considered as whole degrees, and therefore the angle read from that arc is the measure of the distance of the object from its reflected image.

If M N were a mirror perpendicular to C D, the angles B D N E′ D M would be equal, and therefore the ray B D would be reflected from M N in the direction D E′ L, opposite to its direction as reflected from C D. Hence, as seen by an eye in the line D E′ L, the arc I K will be the measure of the supplement of the distance of the object from its reflected image.

When the distance of an object from its image is determined from the inclination of two mirrors, situated as A B and C D are, the eye in the line D E L′ looking towards the object, the angle is said to be measured by a fore observation; but when the supplement of the distance of the object from its image is obtained from the inclination of two mirrors, situated as A B and M N are, the eye in the line D E′ L looking from the object, the angle is said to be determined by a back observation.

The mirror A B is called the index glass, C D the fore horizon glass, and M N the back horizon glass. The horizon glasses are only partly silvered, that objects may be seen through them, as well as by reflection from their surfaces. When the image of an object, as S, reflected from the index and horizon glasses to the eye at E, is in apparent contact with an object, as L, seen by the eye *through* the horizon glass at the same instant, the arc I K measures the angular distance of the objects S and L.

The revolving radius B I is called the *index*, and it is evidently of no importance, provided they revolve together, that it and the index glass A B should be in the same plane. The arc H K, called the *limb*, is generally in quadrants graduated to 20′, and the index carries a scale called, from its inventor, a *Vernier*, the length of the divisions on which are 19′; hence the division on the vernier which corresponds with a division on the limb, points out the minutes which the beginning of the vernier scale has advanced beyond the preceding

division on the limb. In sextants and circles, the divisions on the limb and the vernier are generally more minute, but the principle of division is the same, the following being the general theory of it.

If n be the minutes in each division on the limb, and $m =$ the number of those divisions which are taken as the whole length of the vernier scale, then $m\,n$ is the minutes of the limb which the vernier comprehends; and this is divided into $m + 1$ equal parts for the length of each division on the vernier. Hence $n - \frac{m\,n}{m+1} =$ $\frac{n}{m+1} =$ the difference between the lengths of the vernier and limb divisions, or it is the length of the parts into which the vernier scale subdivides the divisions on the limb. If $n = 20'$, and $m = 19'$, then $\frac{n}{m+1} = 1'$, if $n = 10'$ and $m = 59'$, then $\frac{n}{m+1} = 10''$, &c.

If when A B and C D are parallel, (see the last figure,) or A B and M N perpendicular to each other, the beginning of the divisions on the vernier does not coincide with the beginning of the divisions on the limb, their distance is called the *index error*, subtractive, of course, from the arc read from the limb, as the measure of an angle, when the vernier division is to the left, and additive when to the right of the first division on the limb. If the first divisions on the scales coincide when the mirrors are parallel, the instrument has no index error, and the arc pointed out by the index is the measure of the required angle.

As the angle S E L is double the angle B G D, the image of S will coincide with itself, when A B and C D are parallel; and, for a like reason, when A B and M N are perpendicular, S will be diametrically opposite to its image, as reflected from M N.

A telescope is sometimes applied to guide the sight, and, from its magnifying power, to enable the observer to mark the contact of the objects observed with greater exactness.

The adjustments of the instruments are, to make all the mirrors *perpendicular*, and the axis of the telescope *parallel* to the plane of the instrument; the fore horizon glass *parallel*, and the back one *perpendicular* to the index glass, when 0 on the vernier coincides with 0 on the limb.

There are various screws for making these adjustments, the method of doing which, as well as of using the instruments, will be best learned by practice, under the direction of a skilful teacher; but the following concise directions for making the requisite adjustments may be found useful.

The frame which holds the index glass is fastened to the index by means of two screws behind it; and behind these is an adjusting screw. Having placed the index about the middle of the limb, as B I

(see the last figure) is placed, turn the face of the instrument upwards, and look obliquely into the glass; and if the image of H I appears on a level with H I itself, as seen by the eye, the index glass is perpendicular to the plane of the instrument; but if the image appears *lower* than H I, tighten the adjusting screw; if *higher*, slacken the adjusting screw till the limb H I and its image, seen by reflection in the glass, appear one continued plane.

Then to effect the parallel adjustment of the horizon glass, make 0 on the index exactly coincide with 0 on the limb; fasten the clamp behind the index, and, looking towards the horizon through the sight vane or telescope, loosen the clamp of the lever which moves the horizon glass, and by means of the screw connected with the lever, or the nut at its extremity, move the horizon glass till the image of the horizon seen in the silvered part of the glass is in a straight line with the same object seen through the transparent part.

To make the horizon glass perpendicular to the plane of the instrument, incline the instrument to one side, with its face upwards, and looking as before, towards the horizon, if it and its image appear still a straight line, no adjustment is required; if the image appears to rise above the horizon, as seen directly, *slacken* the sunk screw before, and *tighten* that behind the glass, till the image and the object appear as one line; if the image appear lower, *slacken* the back screw and *tighten* the fore one.

This adjustment is made in some instruments by means of a screw passing through the frame, and in others by a screw behind, turned by a key, or a small capstan-pin, which is put into a hole in the head of the screw.

When the instrument is furnished with a telescope, this adjustment is generally made thus,—screw a dark glass on the end of the telescope, and looking at the sun, make the two images pass over each other, and if they do not exactly cover each other in passing, turn the screw for the perpendicular adjustment of the horizon glass, till they do so. The adjustment may be made with equal readiness by means of the moon or a star, without the use of the dark glass.

In sextants, the index glass is generally *fixed* in its situation by the maker, so that it cannot be directly adjusted; and in the best instruments, the apparatus for the parallel adjustment of the horizon glass is also omitted; so that it is indispensably necessary to determine the index error.

To make the axis of the sextant telescope, when it is an inverting one, parallel to the plane of the instrument, turn the eye-piece of the telescope till two of the parallel wires in its focus appear parallel to the plane of the instrument; and bring the sun and moon, the moon and a bright star, or two bright stars, being 90° or more distant from each other, in apparent contact, on the wire next the instrument; in-

stantly bring them to the other wire, on which, if they still appear in contact, no adjustment is required; if they separate, *slacken* the screw *farthest* from the instrument, in the ring which holds the telescope, and *tighten* the other; and *vice versa* if they overlap. On a few repetitions this adjustment may be made perfect, and it is not very liable to alter.

To find the index error, move the index till the horizon, or any distant object, coincides with its image, and the distance of 0 on the index from 0 on the limb is the index error; subtractive when 0 on the index is to the left, and additive when it is to the right of 0 on the limb.

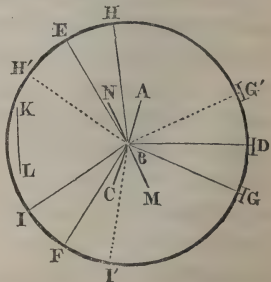
Or, holding the instrument horizontally, move the index forward till the sun and his image appear to touch at the edges, and the difference between the reading on the limb and the sun's known diameter at the time, is the index error; subtractive when the reading is the greater, and additive when it is the less.

Or, in the same manner, make the images touch at the edges, right and left, and when the readings are one right and the other left of zero on the limb, half their difference is the index error; but when they are both right, or both left of zero, half their sum is the index error; subtractive when the greater reading is left, and additive when it is right of zero.

Note.—When the readings are on different sides of zero, one fourth of their *sum*, but when they are on the same side of zero, one fourth of their *difference* is the sun's semidiameter.

The reflecting circle differs from the quadrant or sextant chiefly in having the complete circle graduated, and the measure of the required angle pointed out by three indexes, placed at equal distances from each other, one of which, having a screw attached to it, is called the leading index. Angles are measured by this instrument, on each side of 0 on the arc, by reversing the face of it; and the mean of the measures on each side of 0 is the true measure of the angle, independent of the index error.

In the annexed figure, let B D, B E, and B F be the position of the leading and other indexes when the revolving central mirror is parallel to the fixed one K L. Let A C and M N be two positions of the revolving mirror, when it is equally inclined to K L. Then the arcs D G, D G′, E H, E H′, F I, F I′, passed over by B D, B E, and B F, will be all equal; and if, when the mirror has the position M N, the face of the instrument be reversed, M N and K L will then have the same relative position to each other that A C



and K L have; and, consequently, if an object is seen by reflection from A C and K L, it will also, when the instrument is reversed, be seen by reflection from M N and K L by an eye placed in the same situation; hence the degrees, &c., on the arcs G G′, H H′, I I′, are each the measure of double the distance of the object and its reflected image; it is evident, therefore, that, in observing with the instrument in this manner, its index error does not affect the measure of the required angle.

NAUTICAL ASTRONOMY.

DEFINITIONS AND PRINCIPLES.

Astronomy is the science which treats of the heavenly bodies, their distances, appearances, and the laws by which their motions are governed; and *Nautical Astronomy* is that application of the principles of the science by which, from the angular positions of celestial objects, with respect to each other and to the horizon, the mariner is enabled to determine his situation at sea.

The sun, which to us is the fountain of light and heat, is an immense spherical body, of about 880,000 miles in diameter, and it is the centre round which eleven other bodies, called planets, are known to revolve at different distances, and in different periods. The planes in which the planets revolve all pass through the centre of the sun, and they are in general inclined to each other in very small angles. They are called *primary planets;* and several of them are attended by smaller ones, called *satellites*, which revolve round them, in the same manner as they revolve round the sun.

The sun and the planets are called the *solar system.* The orbits of the planets are not strictly circular, but elliptical or oval; and the sun is situated nearer one extremity of the longer axis than the other, in a point in that axis called the *focus:* so that the planets at one period of their revolutions are nearer to the sun than at another; and when they are nearest to him, their velocities are greatest; the fundamental law of planetary motion being, that *a line drawn from the planet to the sun describes equal areas round him in equal times.*

Besides this periodical revolution round the sun, each of the planets has a uniform rotatory motion round an imaginary line, called the *axis*, passing through the centre; and during the whole of any planet's revolution, its axis of rotation preserves the same parallel position. In consequence of this rotation, the different parts of the surfaces of the planets are presented to the sun in succession; but it has not been observed that the axis round which any planet rotates is perpendicular to the plane in which it revolves round the sun; therefore at one period

of the revolution one extremity of the axis and the adjacent parts of the surface will be inclined towards the sun, and the other at the opposite period.

There is a class of bodies called *comets*, which also revolve round the sun, and appear to be governed in their motions by the same laws that regulate the motions of the planets. Their orbits are greatly elongated, and they come towards the sun from all quarters of the heavens, differing in this respect from the planets, which revolve pretty nearly in the same plane.

The planets become visible or shine only by reflecting the light of the sun, and they can therefore be seen only when some part of their surface on which the sun shines is turned towards the observer.

The *earth* on which we live is one of the planets; it revolves round the sun in a year, and performs its rotation on its axis, from west to east, once in a day. The *moon* is a satellite attending the earth, round which it revolves, from west to east, in about 27 days 8 hours, at a mean distance of about 240,000 miles.

The planets, in the order of their distances from the sun, are *Mercury*, *Venus*, the *Earth*, *Mars*, *Vesta*, *Juno*, *Ceres*, *Pallas*, *Jupiter*, *Saturn*, and *Herschel*.—*Mercury*, and *Venus*, which are nearer the sun than the earth, are called *inferior* planets; and those which are more distant are called *superior* planets. Jupiter, Saturn, and Herschel, are by far the largest; and Vesta, Juno, Ceres, and Pallas, which are all nearly at the same distance from the sun, are so small that they are generally termed *Asteroids*. Jupiter has four satellites, Saturn seven, and Herschel six; and Saturn is besides surrounded by a thin, broad, and beautiful ring, perfectly detached from his body.

The mean distance of the earth from the sun is 95,000,000 miles, and the mean distances of all the planets are nearly proportional to the following numbers,

Mercury,	Venus,	Earth,	Mars,	Asteroids,	Jupiter,	Saturn,	Herschel.
4	7	10	16	28	52	100	196

Hence, from the mean distance of the earth, that of any of the other planets may be obtained by proportion.

When an inferior planet is between the earth and the sun, its dark side being turned towards the earth, it cannot of course be seen by us, unless as a spot apparently passing over the surface of the sun; but it can be so seen only when it passes the sun in one of those points at which its orbit crosses the plane of the orbit of the earth. These points are called the *nodes* of the planet's orbit.

The moon in like manner is invisible when she is in the vicinity of the sun, or at new moon, and she appears like a full circle when she is in the opposite quarter of the heavens; and the various appearances which she exhibits in other situations are merely those which arise

from a greater or less portion of her enlightened hemisphere being seen from the earth; but the convex edge of the visible part is always turned towards the sun.

When the moon passes directly between the earth and the sun she intercepts his light, and forms a *solar eclipse;* and, when at full, the earth is between the moon and the sun, it intercepts the light of the sun, and produces a *lunar eclipse;* the moon in that case passing through the earth's shadow, as the moon's shadow in a solar eclipse passes over the earth.

The inferior planets, when viewed through a telescope, present all the varying appearances of the moon; but as the superior ones are never between the earth and the sun, the apparent form of their visible discs undergoes a comparatively inconsiderable change.

From the rotation of the planets, the axes round which they revolve are shortened, and the diameters perpendicular to them, or their equatorial diameters, are lengthened; that is, they are flattened at the poles. This is particularly observable in the larger planets, and which have besides a quick rotation. Jupiter's equatorial diameter is to his polar one nearly as 14 to 13, Saturn's as 12 to 11, and the earth's as 301 to 300. The earth is therefore much less flattened by its rotation, or it is more nearly spherical, than either Jupiter or Saturn; and the cause is obvious, for Jupiter and Saturn are both immensely larger than the earth, and they revolve also in less than half the time.

Besides the bodies which form the solar system, whose positions, both real and apparent, are continually varying, there are numberless other stars, which shine by their own light, and whose relative situations appear not to be subject to any such change. They are called *fixed stars*, and their distance is so great that the whole extent of the solar system is absolutely as nothing when compared with it. Therefore, from whatever part of the earth's orbit the fixed stars are viewed, their apparent situations in space are the same.

The vicissitudes of day and night are produced by the diurnal rotation of the earth on its axis; and the inequality of the days and the alternations of the seasons, by the inclination of its axis to the plane of its orbit.

It is not however the *real*, but the *apparent* motions of the heavenly bodies that are the objects of consideration in Nautical Astronomy; and all the apparent motions would be the same if the earth were conceived to be stationary, the sun to revolve annually among the fixed stars in the plane of the earth's orbit, the planets at the same time performing their apparent evolutions round him on the immeasurably distant concavity of the celestial sphere, and that sphere, with the sun, stars, and planets, to revolve daily round the earth, from east to west.

The plane of the earth's orbit, or the circle in which the sun appears to move among the stars, is called the *ecliptic*, and circles perpendicular to it are called circles of celestial latitude.

The axis of the earth produced to the heavens points out the celestial poles, or the points round which the apparent diurnal revolution of the celestial sphere is performed; the terrestrial equator produced to the heavens is called the celestial equator; the meridians produced in like manner are called celestial meridians; and the parallels of latitude similarly produced are called parallels of declination.

The ecliptic intersects the equator in two points, called equinoctial points; that at which the sun crosses from the south to the north side of the plane of the equator is called the first point of Aries; Aries being the first of twelve equal parts, called signs, into which astronomers divide the ecliptic.

From the attraction of the sun and moon on the protuberant parts of the earth about the equator, the equinoctial points move westward along the ecliptic about 50″ in a year; this motion is called *the precession of the equinoxes.*

The sign of the ecliptic, in order, with their distinguishing marks, are as follows, viz.:

Signs.	Aries,	Taurus,	Gemini,	Cancer,	Leo,	Virgo,
Marks.	♈	♉	♊	♋	♌	♍
Signs.	Libra,	Scorpio,	Sagittarius,	Capricornus,	Aquarius,	Pisces.
Marks.	♎	♏	♐	♑	♒	♓

The inclination of the equator to the ecliptic is called the *obliquity of the ecliptic.*

The latitude of a celestial body is an arc of a circle of latitude intercepted between the object and the ecliptic, and it is called north or south, according as the object is on the north or south side of the ecliptic; and the longitude of a celestial object is the arc of the ecliptic intercepted between the circle of latitude passing over the object and the first point of Aries, estimated in the order of the signs.

The declination of a celestial object is its distance from the celestial equator measured on the meridian passing over the object, and it is called north or south according as the object is on the north or south side of the equator; and the right ascenion of a celestial object is the arc of the equator intercepted between that meridian and the first point of Aries, estimated, like the longitude, in the order of the signs. The right ascension of any meridian is the same as that of a celestial object conceived to be on the meridian.

The *sensible horizon* is a plane conceived to touch the earth at the point at which an observer is situated; and the *rational horizon* is a plane parallel to the sensible one passing through the centre of the earth.

The pole of the horizon vertically over an observer is called the *zenith*, and the opposite point the *nadir*. The zenith is at the same angular distance from the celestial equator that the observer himself is from the terrestrial one.

Great circles perpendicular to the horizon, and which of course meet in the zenith, are called *vertical circles*, *azimuth circles*, or *circles of altitude*. The angle which the vertical circle passing over any object makes with the meridian passing through the zenith, or the arc of the horizon which these circles intercept, is called the *azimuth* of the object.

The vertical circle which is at right angles to the meridian is called the *prime vertical*, and it meets the horizon in the east and west points; the meridian meeting it in the north and south points.

The *amplitude* of an object is the angle included between the prime vertical, and the vertical circle on which the object rises or sets; or it is the angular distance of the object at rising or setting from the east or west points of the horizon.

Small circles parallel to and above the horizon are called parallels of altitude, and the small circle 18° below the horizon is called the twilight circle, because the twilight begins in the morning and ends in the evening when the sun is on that circle.

The polar distance of an object is its distance from the pole nearest the zenith of the observer, and it is consequently equal to the sum or difference of a quadrant and the declination, according as the latitude and declination are of a contrary or the same denomination.

A *sidereal day* is the interval between two successive transits of a *fixed star;* and a *solar* or an *apparent day* is the interval between two successive transits of the *sun* over any meridian. The sidereal day commences when the first point of Aries is on the meridian, and the solar or astronomical day when the sun is on the meridian. The *sidereal time* of day is measured by the arc of the equator, or the angle at the pole between the first point of Aries and the meridian of the observer, estimated from the meridian *westerly;* and the solar or *apparent time* of day is measured by the arc of the equator, or the angle at the pole intercepted between the meridian on which the sun is, and the meridian of the observer, estimated also from the meridian *westerly.*

Hence the solar time added to the sun's right ascension is the sidereal time, or the sun's right ascension taken from the sidereal time leaves the solar or apparent time.

A mean solar day is longer than a sidereal one, for the sun daily advances in the ecliptic so far towards the east that the mean interval between his transits is about 3m 56s greater than the interval between the transits of a fixed star. The sidereal days are all perfectly equal, but from the variable angular motion of the sun in the ecliptic (a circle inclined to the equator) his daily change of right ascension is a variable quantity, and hence he comes to the meridian at unequal intervals of time. *Mean time* is that which would be shown by the sun if he revolved in the plane of the equator with the mean angular

velocity with which he revolves in the ecliptic; the difference between mean and apparent time is called the *equation of time*.

Chronometers for nautical purposes, as well as clocks and watches for use in ordinary life, are regulated by mean time, but observatory clocks by sidereal time; because when an object is on the meridian, the sidereal time is its right ascension, which in observatories it is one of the chief objects to determine.

The meridian distance of a celestial object is the angle at the pole, included between the meridian on which the object is, and the meridian of the observer.

The semidiurnal arc is the arc of the parallel of declination which a celestial object describes, between the time of its rising or setting, and that of its passing the meridian, and it is measured by the corresponding arc of the equator.

The ascensional difference is the difference between the semidiurnal arc and six hours.

From what has been said on the subject of time, it is evident that the difference between the time at Greenwich, and that at any other place, is measured by the same arc of the equator which measures the longitude of that place, whether the time is *apparent*, *mean*, or *sidereal;* the circumference of the equator, or 360°, representing 24 hours of time. *Hence the problem of finding the longitude by observation requires us to be able to determine the time at the place at which we are, and the time at the same instant at the meridian of Greenwich.*

The *apparent altitude* of a celestial object is the arc of a vertical circle intercepted between the centre of the object and the sensible horizon, the eye being on the surface of the earth; and the true *altitude* is the arc of a vertical circle intercepted between the centre of the object and the rational horizon, the eye being conceived to be at the centre of the earth. The true and apparent zenith distances, or the true and apparent distances of the object from the zenith, are the complements of the true and apparent altitudes. The altitude and zenith distance of an object, when on the meridian, are called the *meridian altitude* and *meridian zenith distance* of that object.

But altitudes, if observed on or above the surface of the earth, require several corrections before the true altitudes can be deduced from them. These corrections are for *semidiameter*, *dip*, *refraction*, and *parallax*. By the *semidiameter* of a celestial object, is meant the angle which the radius of its apparent circular disc subtends at the eye of the observer; and by the *parallax*, the angle which that radius of the earth on which an observer is situated subtends at the centre of the object. When the object is in the horizon, the semidiameter and parallax are called the horizontal semidiameter and horizontal parallax; and the parallax, at any altitude, is called the parallax in altitude.

The sun's semidiameter *was* given in the Nautical Almanac for every sixth day of the month, and since 1834 it is given for every day. His mean horizontal parallax is about $8\frac{3}{4}''$, and it never differs more from that quantity than about a quarter of a second. His parallax, at any altitude, may be taken by inspection from Table 10, and his semidiameter, with sufficient exactness, from Table 16; but for common purposes, the semidiameter may be always taken at 16′.

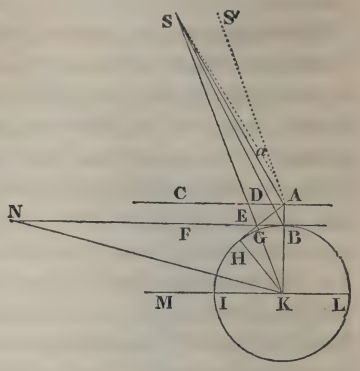
The moon's horizontal parallax and semidiameter, as seen from the centre of the earth, are given in the Nautical Almanac for every noon and midnight of Greenwich time. The parallax there given is the horizontal parallax of the earth's greatest or equatorial radius, and the reduction, to adapt it to any particular latitude, may be taken from Table 12. The parallaxes of the sun and the planets are so small, that this correction, with respect to them, is too minute to be regarded. The moon's parallax is to its semidiameter always very nearly as 11 is to 3. Her apparent semidiameter is greater as her altitude increases, as she is then nearer to the observer. This augmentation of her semidiameter may be taken from Table 14.

When the eye is above the surface of the earth, the visible horizon appears depressed, as the line from the eye, touching the horizon, is a tangent to the earth at the point of contact. The depression of this line below the horizontal plane passing through the eye of the observer, is called the dip; and the altitude, as observed, as well as its supplement, are too great by this depression. The correction for dip is therefore *subtractive;* it may be taken, by inspection, from Table 7.

When a ray of light passes obliquely from one medium into another of greater density, it is bent towards the perpendicular at the point at which it enters. This bending is called refraction. Now the strata of the atmosphere, through which the rays of light pass to the earth, increase in density as they approach the surface, being compressed by the weight of the superincumbent atmosphere; and therefore the rays of light from celestial objects are bent downwards as they approach the earth; and, consequently, to us, all celestial objects appear more elevated than they would do, or their altitudes are greater than they would be, if light were not refracted.

Except near the horizon, the refractions at different altitudes are nearly proportional to the cotangents of the altitudes. In a mean state of the atmosphere, the refraction at the horizon is 33′. Table 9 contains the mean refractions, and Table 11 their corrections for any variation in the temperature or density of the atmosphere.

To explain more clearly the effect of these corrections on altitudes, let M I K L be a section of the rational, and N B a section of the sensible horizon, A B the elevation of the eye of an observer above the surface of the earth, and A C a plane parallel to M L. Let N be the place of a celestial object when in the horizon, S its true place when above the horizon, S *a* A the course of a ray of light from it to the eye at A, A S′ a tangent to the curve S *a* A at the point A, and A H a tangent drawn from A to the earth's surface at H; then S A S′ will be the refraction, C A H = B K H the dip, B N K the horizontal parallax, and B S K the parallax in altitude; S′ A H the observed, S B N the apparent, and S K M the true altitude, which is measured by the arc G I. Now even in the case of the moon, the parallactic angle B S K will not in any case much exceed a degree; and as it is subtended by B K, which is nearly 4000 miles, the angle A S B subtended by A B, which on ship board cannot exceed a few feet, may be considered as evanescent; and therefore the angles S A C and S D C, or S B F, may be considered as equal. Whence S′ A H (the observed altitude) − C A H (the dip) − S′ A S (the refraction) = S A C = S B F; and S B F + B S K = S E F = S K M, the true altitude. And N K and S K being equal, N K : B K :: S K : B K; but N K : B K :: rad : sin B N K and S K : B K :: sin S B K, or cos S B N : sin B S K; consequently, rad : sin horizontal parallax :: cos apparent altitude : sin parallax in altitude; whence, from the horizontal parallax, the parallax in altitude may be computed. The joint effect of the moon's parallax and refraction may be taken by inspection from Table 24.



With respect to the semidiameter of the object, as it is the altitude of the centre that is required, the semidiameter must be added to the observed altitude when the lower edge, or *lower limb*, is observed, and subtracted from it when the upper limb is observed.

When the altitude of an object is taken by what is called a back observation, the depression of the point diametrically opposite to the object is measured; the effect of the dip is therefore to diminish this angle, as it increases the measure of its supplement; in this case therefore the correction for dip is additive.

The altitude corrected for semidiameter and dip is the apparent altitude, and the difference between the remaining corrections, viz.

the parallax in altitude and the refraction, is called the correction of altitude.

The correction for parallax being additive, and that for refraction subtractive, their difference is additive when the parallax, and subtractive when the refraction, is the greater; but it is only in the case of the moon that the parallax exceeds the refraction, and from the distance of the fixed stars their parallax is insensible, therefore the moon's correction of altitude is additive, and that of the sun or of a star subtractive; or the true place of the moon is *above*, and that of any other celestial object *below* its apparent one. Altitudes are sometimes observed on land by reflection, from what is called an artificial horizon, which is in general merely the horizontal surface of a fluid. Thus, in figure 2, page 200, if the reflecting surface A C were horizontal, the angle E, or its equal S B S′, would be double of S B A, the altitude of S. Altitudes can be taken with great exactness by this method, and the seaman should be familiar with the practice of it, as from altitudes so taken on shore he may, at any time, with ease and accuracy, find the error and rate of his chronometer. When the altitude of a celestial object is increasing, it is marked with +, and with − when it is decreasing; hence + affixed to an altitude shows that the object is *east*, and − that it is *west* of the meridian.

The same marks added to a number, taken from a Table, show whether the number is increasing or decreasing. For example, if I take the sun's right ascension for July 4, 1825, from Table 21, thus 6h 52m 43s + 4m 7s, I mean, that the right ascension is 6h 52m 43s at noon, and that its next value given in the Table is 4m 7s greater.

If I take from Table 32 the moon's horizontal parallax for midnight, Greenwich time, September 9, 1823, thus 55′ 55″ — 21″, I mean, that her parallax is 55′ 55″, and that the next following one is 21″ less.

☉ signifies the sun's lower, and ☉̄ his upper limb; ☽ the moon's lower, and ☽̄ her upper limb.

PREPARATORY PROBLEMS.

Problem I.

To convert longitude into time.

Multiply the longitude by 4, divide the degrees of the product by 60, and the quotient will be the hours, the remainder minutes, and the other parts of the product seconds, &c. of the corresponding time.

EXAMPLE.

What time corresponds to 49° 4′ 20″ of longitude?

$$\begin{array}{r} 49^\circ\ 4'\ 20'' \\ \hline 4 \\ \hline 60)196\ 17\ 20 \\ \hline \text{hours}\quad 3\ 16\ 17\ 20 \end{array}$$

EXAMPLES FOR EXERCISE.

	Longitude.				Time.			
	°	′	″		h	m	s	t
1.	154	14	10	equivalent to	10	16	56	40
2.	48	27	00	.....	3	13	48	00
3.	14	2	30	.....		56	10	00
4.	5	16	00	.....		21	4	00
5.	163	2	48	.....	10	52	11	12

PROBLEM II.

To reduce time into longitude.

Reduce the hours and minutes into minutes, and divide all by 4, and the quotient will be the degrees, minutes, &c. of the corresponding longitude.

EXAMPLE.

What longitude corresponds to 7h 2m 46s?

$$\begin{array}{r} \text{h}\ \text{m}\ \text{s} \\ 7\ 2\ 46 \\ 60 \\ \hline 4)422 \\ \hline 105^\circ\ 41'\ 30'' \end{array}$$

EXAMPLES FOR EXERCISE.

	Time.				Longitude.		
	h	m	s		°	′	″
1.	3	4	56	equivalent to	46	14	00
2.	5	2	19	.....	75	34	45
3.		14	3	.....	3	30	45
4.	11	45	38	.....	176	24	30
5.	18	29	9	.....	277	17	15

Problem III.

To express civil time astronomically.

If the given civil time be P.M., the astronomical and civil time will agree; but if the civil time be A.M., add 12 hours to it, and the sum will be the corresponding astronomical time after the noon of the preceding day.

For example, October 4th, at 2h 10m 3s P.M. civil time, is also October 4th, 2h 10m 3s astronomical time; but September 1st, 8h 4m 20s A.M., is August 31st, 20h 4m 20s astronomical time.

Examples for Exercise.

	Civil Time.						Astronomical Time.			
		h	m	s				h	m	s
1.	June 5th	4	10	3	A M	is	June 4th	16	10	3
2.	Dec. 29th	3	2	7	P M	....	Dec. 29th	3	2	7
3.	Aug. 14th	6	28	40	P M	....	Aug. 14th	6	28	40
4.	Feb. 26th	9	58	3	A M	....	Feb. 25th	21	58	3
5.	July 7th	7	12	56	A M	....	July 6th	19	12	56

Problem IV.

From the time at any place, and the longitude of that place, to find the corresponding Greenwich time.

Reduce the longitude into time by Problem I; and if west, add it to the astronomical time at the given place, but subtract it if east, and the sum or remainder will be the Greenwich time.

If, in adding, the sum should exceed 24 hours, the excess will be the Greenwich time, past noon, of the following day; and if, in subtracting, the longitude in time should exceed the astronomical time at the place, subtract the longitude in time from the given time, *increased by* 24 *hours*, and the remainder will be the Greenwich time, past noon, of the preceding day.

Examples.

1. In longitude 21° 4′ W., on September 13th, at 8h 40m 3s A. M., required the astronomical time at Greenwich?

	h	m	s
Astronomical time, September 12th	20	40	3
Longitude in time W.	1	24	16
Astronomical time at Greenwich . .	22	4	19

2. In longitude 85° 24′ E., on July 20th, at 3h 35m 7s P. M., required the Greenwich time?

	h	m	s
Given time P. M.	3	35	7
	24		
	27	35	7
Longitude in time E	5	41	36
Greenwich time, July 19th	21	53	31

Examples for Exercise.

	Civil Time.	Longitude.	Astronomical Time at Greenwich.
	h m s	° ′	h m s
1. Oct. 17th	4 23 4 A M	43 12 W	Oct. 16th 19 15 52
2. Feb. 4th	9 16 22 P M	17 4 E	Feb. 4th 8 8 6
3. May 30th	11 3 4 A M	163 28 W	May 30th 9 56 56
4. July 26th	4 00 00 A M	120 00 W	July 26th Noon.
5. Dec. 27th	6 13 51 P M	21 18 W	Dec. 27th 7 39 3
6. Aug. 1st	1 00 8 P M	53 4 E	July 31st 21 27 52

Problem V.

To find the apparent time at which any celestial object culminates, or passes the meridian of a given place, on a given day.

From the object's right ascension for the noon of the given day, increased, if necessary, by 24 hours, subtract the sun's right ascension at noon, and the remainder is the required time nearly. To this add the longitude in time if west, but subtract it if east, and the sum or the remainder will be the Greenwich time nearly. To the logarithm of this Greenwich time, from Table 30, add the logarithm of the daily change of the sun's right ascension, from the same table, taking hours and minutes for minutes and seconds, and the sum is the logarithm of a correction, to be found in the same table, calling hours and minutes minutes and seconds; subtract this correction from the time *nearly*, found before, and the remainder will be the required time, *still more* nearly. If still greater exactness is required, the operations may be repeated; but this will seldom be necessary. In this manner may the time be found at which any object passes the meridian; but if the time of the moon's meridian passage be required, *merely to prepare for observing her meridian altitude, or to determine the latitude from an observed meridian altitude*, it may be found with sufficient exactness for nautical purposes, by adding to the time of her passing the meridian of Greenwich, the correction from Table 17, in west, but subtracting it in east longitude.

Example I.

At what time will Altair pass the meridian of Petersburg, October 11th, 1823?

	h	m	s	
✳'s R A Jan. 1st, 1820, Table 23,	19	42	0	+ 2″·93 annual variation.
2·93 × 3·8 years =		+	11·1	
✳'s R A at given time.....	19	42	11·1	
☉'s R A at noon, Tab. 21.....	13	4	1	+ 3m 41s. Tab. 30 ·8140
Required time nearly	6	38	10·1	
Longitude 30° 19′ E in time....	2	1	16	
Greenwich time	4	36	54	Log Table 30 .. ·7159
Cor. sub. fr. required time nearly			42·5	prop log 1·5299
Required time	6	37	27·6	

Example II.

Required the time at which the moon will pass the meridian of 40° W, September 10th, 1823?

	h	m
Per Naut. Alm. (see Tab. 31) ☽ on the meridian of Greenwich	4	32
And on the following day	5	23
Difference		51

To 51m and long. 40° W, in Table 17, corresponds 5m, which added to 4h 32m gives the required time 4h 37m.

Examples for Exercise.

At what time will the following celestial objects pass the meridian of the places respectively named in each question on the given day?

Object.	Date.	Place.	Answer. Time of culminating. h	m	s
1. Fomalhaut..	April 14th, 1839..	Cape of Good Hope	21	17	21
2. Sirius	Oct. 11th, 1857..	Genoa	17	29	24
3. Capella.....	Nov. 5th, 1824..	New York.....	14	18	11
4. Aldebaran...	Dec. 10th, 1869..	Canton	11	17	41
5. Pollux.....	Aug. 5th, 1873..	Cadiz	22	31	41
6. ☽	Sept. 11th, 1823..	Rio Janeiro.....	5	28	00
7. ☽	Sept. 26th, 1823..	Constantinople	17	40	00

Problem VI.

From the observed altitude of a fixed star to find its true altitude.

Correct the observed altitude for the index error of the instrument, subtract the dip (Table 7) if the altitude be taken by a fore observation, but add it if by a back observation, and the sum or remainder will be the apparent altitude, from which subtract the refraction (Table 9) corresponding to the altitude, correcting the refraction by Table 11, when necessary, and the remainder will be the true altitude.

Remark. *When it is not otherwise stated, the altitudes in every example in this book are to be understood as taken by a fore observation.*

Example.

If the altitude of a star be 43° 12′, height of the eye 18 feet, required its true altitude, the index error of the instrument being 3′ 46″ – ?

43°	12′	00″	observed altitude.
	3	46	index error of the instrument.
43	8	14	
	4	11	dip.
43	4	3	apparent altitude.
	1	1	refraction.
43	3	2	true altitude.

Examples for Exercise.

The true altitude of the star is required in each of the following examples?

	☼'s observed Alt.		Index Error.		Height of the Eye. Feet.	Answer. True Alt.		
	°	′	′	″		°	′	″
1.	48	26	– 5	3	18	48	15	56
2.	39	17	+ 2	40	12	39	15	6
3.	86	23	– 0	26	17	86	18	26
4.	4	48	+ 1	35	12	4	35	50
5.	7	20	– 1	00	15	7	8	5
6.	24	00	+ 4	2	16	23	57	58

Problem VII.

From the observed altitude of the sun's lower or upper limb, to find the apparent and true altitude of his centre.

Correct the observed altitude of the limb for the index error of the

instrument and the dip, as in the last Problem, and the result will be the apparent altitude of the limb; to which add the semidiameter, if the lower, but subtract it if the upper limb is observed, and the sum or remainder will be the apparent altitude of the centre. From this subtract the difference between the parallax, (Table 10,) and the refraction, (Table 9,) corresponding to the altitude of the observed limb, and the remainder will be the true altitude.

Remark. The difference between the parallax and refraction corresponding to the altitude of the *centre*, is the correction of altitude which must be used in computing the true altitude, when it is required for clearing the apparent distance between the moon and the sun or a star, from the effects of parallax and refraction.

Example.

If the altitude of ☉ be 24° 2′ 40″ on May 17th, index error of the instrument 2′ 23″ +, height of the eye 15 feet, required the true altitude of his centre?

24° 2′ 40″	observed altitude.
+ 2 23	index error.
24 5 3	
− 3 49	dip Table 7.
24 1 14	
+ 15 50	semidiameter, (Nautical Almanac or Table 16.)
24 17 4	
2 00	cor of alt for ref and par (Tables 9 and 10.)
24 15 4	true altitude.

Examples for Exercise.

In each of the following examples the true altitude of the sun's entreis required?

Date.	Observed Alt.	Index Error.	Height of the Eye. Feet.	Answer. True Alt.
	° ′ ″	′ ″		° ′ ″
Sept. 5th.	☉ 40 3 40	− 2 12	16	40 12 26
Oct. 11th.	♉ 28 16 22	+ 4 8	12	27 59 24
Dec. 14th.	☉ 14 3 46	− 5 7	10	14 8 12
Sept. 22d.	☉ 80 45 10	+ 6 3	23	81 2 20
Jan. 4th.	♑ 17 36 12	− 2 40	25	17 9 27

Problem VIII.

From the observed altitude of the moon's upper or lower limb, her semidiameter and horizontal parallax as given in the Nautical Almanac, and the latitude of the place of observation, to find the true altitude.

To the semidiameter from the Nautical Almanac, apply the augmentation corresponding to the altitude from Table 14; and from the horizontal parallax as given in the Nautical Almanac, subtract the reduction corresponding to the latitude, Table 12.

Then correct the altitude for index error and dip, as in the preceding problems, and add or subtract the augmented semidiameter according as the lower or upper limb is observed, and the sum or remainder will be the apparent altitude of her centre, to which add the correction of altitude from Table 24, and the sum will be the true altitude.

Example.

If the apparent altitude of the moon's lower limb be 40° 26′ in latitude 58°, her semidiameter, from the Nautical Almanac, being 16′ 2″. and horizontal parallax 58′ 47″, the index error of the instrument 5′ 2″ +, and height of the eye 14 feet, required the true altitude?

☽'s semidiameter	16′	2″	Horizontal parallax	58′	47″
Aug Table 14...		11	Reduction, Table 12		11
Aug semidiameter	16	13	Reduced parallax	58	36

Table 24.						
			40°	26′	0″	observed altitude ☽.
			+	5	2	index error.
Min. ☽'s Parallax	58′		40	31	2	
☽'s app alt 40° 40′..	42′	47″	−	3	41	dip
4..		4	40	27	21	
Sec parallax 30″..		22	+	16	13	semidiameter.
6..		4	40	43	34	
Cor ☽'s app alt	43	17		43	17	correction of altitude.
			41	26	51	true altitude.

Examples for Exercise.

In each of the following examples, the moon's true altitude is required?

Lat.	Observed Alt.	Index Error.	Hor. Par.	Semidiam.	Height of the Eye. Feet.	Answer. True Alt.
°	° ′ ″	′ ″	′ ″	′ ″		° ′ ″
48	☽ 53 18 20	+ 5 2	58 14	15 53	14	54 9 34
20	☽ 49 2 48	− 4 26	60 27	16 29	19	49 49 28
67	☽ 57 14 23	− 3 11	54 30	14 52	20	57 20 46
32	☽ 63 42 4	+ 4 12	55 29	15 8	12	64 22 3
10	☽ 20 4 57	− 2 0	54 14	14 47	16	20 32 34
39	☽ 6 3 28	+ 1 48	59 38	16 16	23	7 7 55

Problem IX.

To find the polar distance of a celestial object.

When the declination of the object and the latitude of the place are of contrary names, add the declination to 90°; but when they are of the same name, subtract the declination from 90°, and the sum or remainder will be the polar distance.

Examples.

Lat.	Declination.	Polar Dist.
N	28° 14′ S	118° 14′
N	16 3 N	73 57
S	10 40 S	79 20
S	6 32 N	96 32

Problem X.

To find the apparent Greenwich time when the sun is on a given meridian.

The longitude in time, *if west*, is the Greenwich apparent time, after noon of the given day; but if *east*, subtract the longitude in time from 24 hours, and the remainder is the Greenwich apparent time, after noon of the preceding day.

Thus, on May 4th, in longitude 20° east the sun is on the meridian at 24h − 1h 20m = 22h 40m, Greenwich apparent time May 3rd. If the longitude had been *west*, the app time at Greenwich would have been 1h 20m May 4th.

Examples for Exercise.

Required the apparent Greenwich time date, when the sun is on the following meridian, on the days named?

	Long.	Answer. h	m	
1. April 4th	139° E	14	44	April 3rd
2. May 17th	48° W	3	12	May 17th
3. Oct. 4th	76° W	5	4	Oct. 4th
4. Mar. 16th	42° E	21	12	Mar. 15th

This problem is used in getting a Greenwich date for correcting the sun's declination, when the latitude is found by the meridian altitude of the sun, or the error of a chronometer by equal altitudes of the sun.

Problem XI.

To find the apparent Greenwich time when any star is on a given meridian.

To the time of its passing the given meridian, found by Problem 5, apply the longitude in time as in Problem 4, and the result is the required apparent time at Greenwich.

Thus it appears by Prob. 5, that Altair is on the meridian of Petersburg at 6h 37m 27·6s; and the long. of Petersburg, 2h 1m 16s east, subtracted from this, leaves 4h 36m 11·6s, the required Greenwich time.

Problem XII.

To find the Greenwich time on any day when the moon is on a given meridian.

Take the mean time of the moon's passing the meridian of Greenwich and the daily retardation, from the Nautical Almanac, and to the longitude in time add the correction from Table 17. Add this sum to the time of meridian passage at Greenwich, if the longitude is *west*, but subtract it from that time if the longitude is *east*, and the sum or the remainder will be the Greenwich mean time when the moon is on the given meridian.

Example.

The moon passing the meridian of Greenwich in March, 1836, as under, required the Greenwich time when she is on the meridian of 43° W on March 4th.

March, 1836.

Day.	Mer. passage at Greenwich.	
	h	m
1.	11	12·7
2.	12	0·8
3.	12	47·7
4.	13	34·1
5.	14	21·1
6.	15	9·7

It appears that on the given day the moon is on the meridian of Greenwich at 13h 34·1m mean Greenwich time, and the difference to the following day is 47m. In Table 17 with long. 43° and daily difference 47 the correction is about 5·5m, which added to 2h 52m, the longitude in time, gives 2h 57·5m. This added to 13h 34·1m, gives 16h 31·6m, the required mean time at Greenwich.

Examples for Exercise.

Required the mean Greenwich time when the moon is on the following meridians, on the days respectively named?

	1836.	Long.	Answer. h	m	
1.	March 2nd	139° E	2	27·3	March 2nd
2.	March 4th	67° W	18	10·1	March 4th
3.	March 5th	58° W	18	21·1	March 5th
4.	March 5th	58° E	10	37·1	March 5th
5.	March 3rd	112° W	20	28·7	March 3rd

Problem XIII.

To find what bright star will be on the meridian first after a given hour.

To the apparent time add the sun's right ascension, and the star in Table 23, or any other catalogue of stars, whose right ascension is next greater than the sum, is the required star.

Thus, at 9h P. M. app. time, when the sun's right ascension is 4h 2 m, the star Spica, whose right ascension is next greater than 13h 2m, is the bright star that may be first expected on the meridian.

Note. In this problem the sun's right ascension may be taken for noon of the given day.

Examples for Exercise.

What bright star will pass the meridian first after the hours named on each of the following days?

		h	m	Answer.
1.	Sept. 5th, 1823	9	10	..... α Pavo.
2.	April 9th, 1826	10	17	..... Deneb, Leo.
3.	Oct. 24th, 1822	7	20	..... Alderamin, Cepheus.
4.	June 11th, 1825	11	15	..... Ros Algethi, Hercules.

Problem XIV.

To find the sun's declination, &c. for any given hour of Greenwich time.

Take the required element and its daily change, from the Nautical Almanac or other Tables, for the mean or apparent Greenwich noon of the given day, as it may be given; and add together the logs from Tab. 30 of the Greenwich time and the daily change, taking minutes and seconds, if necessary, for hours and minutes in the Table, and the sum is the log of the correction in the same Table, taken in the same manner as the daily change is found. Add this to the value at the preceding noon, if increasing, but subtract it, if decreasing, and the result is the value at the given time.

Example.

Required the sun's right ascension and declination, and the equation of time, Aug. 24th, 1823, at 13h 40m Greenwich time?

	Greenwich time 13h 40m	Tab. 30, 2446
⊙'s declin Aug. 24, 1823, Tab.19, 11° 19′ 10″ — 20′ 21″	ditto	717
Cor. — 11 35	ditto	3163
11 7 35 Declination.		

Here 20′ 21″ is taken as 20h 21m; and 11′ 35″ is put for 11h 35m.

	Greenwich time 13h 40m	Tab. 30, 2446
⊙'s R.A. Aug. 24, 1823, Tab. 21, 10h 10m 9s + 3m 41s	ditto	8140
Cor. 2 5	ditto	10586
10 12 14 Right asc.		

Here 3m 41s is taken as 3h 41m, and 2m 5s is put for 2h 5m.

	Greenwich time 13h 40m	Tab. 30, 2446
Eq. Time, Aug. 24, 1823, Tab. 22, 2m 19s — 16s	ditto	1761
Cor. 9·1	ditto	4207
2 9·9 Eq. time.		

Here 16s is taken as 16h, and the correction, which in the Table is 9h 7m, is taken as 9s 7th = 9s·1 nearly.

When the daily change exceeds the limits of the Table, enter with one half of it, and double the result.

In the same way may the right ascension and declination of a planet be taken from the Nautical Almanac.

Examples for Exercise.

Required the sun's right ascension, declination, and the equation of time for the Greenwich apparent time dates in each of the following examples?

	Greenwich App. Time.	Answer. Declination.	Rt. Asc.	Eq. Time.
	h m s		h m s	m s
1.	Oct. 6th, 1824 6 42 12	5° 18′ 33″ S	12 49 27	11 58·7 sub
2.	May 27th, 1825 20 46 15	21 26 31 N	4 19 14	3 9·0 sub
3.	Nov. 14th, 1822 18 3 40	18 22 34 S	15 19 44	15 16·5 sub
4.	Feb. 6th, 1823 2 12 18	15 44 18 S	21 18 4	14 24·4 add

Problem XV.

To find proportional parts of the change of the moon's right ascension, declination, &c., for intervals between every third hour.

To the proportional logarithm, Tab. 29, of the change in 3h, add the proportional logarithm of the time past the preceding third hour, and the sum is the proportional logarithm of the required proportional part.

Example.

What is the change of the moon's right ascension in 1h 47m 20s, when in 3h it is 1° 36′ 35″?

	1h 47m 20s prop log	·2245
	1° 36′ 35″ ditto	·2704
Req change	0° 57′ 36″ ditto	·4949

This change applied to the value at the preceding third hour will give the value at the given instant, second differences (that is the variations in the *rate of change* during the interval) being neglected.

Examples for Exercise.

Required the moon's right ascension and declination at each of the following Greenwich dates, using only even proportion, and taking them for every third hour from Table 32?

		Answer.	
		Rt. Asc.	Declination.
	h m s	h m s	° ′ ″
1. Sept. 4th, 1823	4 20 10	10 33 15	5 28 39 N
2. Sept. 19th, 1823	14 3 55	23 27 6	1 4 4 N
3. Sept. 7th, 1823	8 26 9	13 15 46	13 32 52 S
4. Sept. 22nd, 1823	22 5 46	2 10 41	18 27 8 N

Problem XVI.

The moon's right ascension, declination, &c., being given for every third hour, to find them exactly at intermediate times.

Find, as in the last problem, the approximate value, which, in general, will be sufficiently exact for ordinary purpose.—But when the greatest precision is required, take the two values which precede, and the two which follow the given time, and half the difference between the sum of the first and fourth, and that of the second and third, is the second difference. Reduce this into seconds, and multiply it by the number from the following table, taking the argument at the top, and if the sum of the first and fourth is the less, *add* the product to the approximate value of the right ascension already found; if the reverse, *subtract* it; and the sum or the remainder will be the correct value.—But always add the correction to the approximate, to find the correct declination.

Note. When the declination changes from north to south, the correction for second differences may be disregarded.

Table of multipliers for second differences for intervals of three hours and one hour.

Time past the preceding 3rd hour.	h m 0 0 3 0	h m 0 15 2 45	h m 0 30 2 30	h m 0 45 2 15	h m 1 0 2 0	h m 1 15 1 45	h m 1 30 1 30
Multiplier for second diff.	·000	·038	·069	·094	·111	·121	·125
Time past the preceding hour	h 0 1	m 5 55	m 10 50	m 15 45	m 20 40	m 25 35	m 30 30

Example.

Required the moon's declination Sept. 24th, 1823, at 13h 15m?

☽'s declin Sept. 24th.

9h	23° 36′ 44″		
12	23 56 9		
15	24 14 16		
18	24 31 2		
	48 7 46		
	48 10 25		
	2) 2 39		
	1 19·5 = 79″·5 second diff +.		

1h 15m prop log ·3802

+18′ 7″ ditto ·9972

1·3774 prop log

	23° 56′ 9″
prop log	+ 7 33
Approximate declin	24 3 42
Cor	+ 9·6
Correct declin	24 3 51·6

Below 1h 15m stands ·121, and ·121 × 79′·5 = 9″·6, the correction for second diff +.

Examples for Exercise.

Required the *correct* right ascension and declination of the moon in each of the examples to the last problem?

	Answer.	
	Rt. Asc.	Declin.
	h m s	° ′ ″
1.	10 33 15·2	5 28 41 N
2.	14 3 54·9	1 4 4 N
3.	8 26 9	13 32 55 S
4.	22 5 44·6	18 27 12 N

Problem XVII.

To find the right ascension and declination of the moon for any given Greenwich time, when given for every hour, as they are now in the Nautical Almanac.

Take the right ascension and declination for the given hour, and the change to the succeeding one, from the *Nautical Almanac;* and to the proportional log of this change, add the proportional log of the minutes and seconds in the given Greenwich date, and the constant log. 9·5229, and the sum, rejecting 10 from the index, will be the proportional log of the part for minutes and seconds, to be added to or subtracted from the element at the given hour, according as it is increasing or decreasing.

The proportional part of the right ascension may be found more conveniently and accurately, if the decimals of seconds on the hourly difference be reduced to thirds, and the minutes, seconds, and thirds be then taken as hours, minutes, and seconds; and the hours, minutes, and seconds in the result be accordingly taken as minutes, seconds, and thirds, respectively.

Example.

Let it be required to find the right ascension and declination of the moon on a given day at 4h 13m 46s, when on that day at the corresponding hours, the *Nautical Almanac* shows the right ascension and declination to be as follows:

	Rt. Asc.			Declin.		
h	h	m	s	°	′	″
3.	2	50	23·29	14	58	52·3
4.	2	52	17·78	15	10	5·2
5.	2	54	12·44	15	21	14·3
6.	2	56	7.27	15	32	19·6

Here the change of declination from 4h to 5h is 11′ 9″·1, and of right ascension 1m 54·66s = 1m 54s 39·6th, which take as 1h 54m 39·6s.

Time past 4h,	0h 13m 46s P L 1·1164		1·1164
Hrly. ch. of R. A.,	1h 54m 39·6s P L 1958	Hrly. ch. of Declin. 11′ 9″·1 P L	1·2079
	Const. 9·5229		9·5229
Cor. R. A.	26m 19s P L 8351	Cor. Declin. 2′ 23″·5 P L	1·8472

	Or 26s 19m = 26·32s	Declin. at 4h	15° 10′ 5″·2
R. A. at 4h	2h 52m 17·78s	Req. Declin.	15° 12′ 38″·7
Req. R. A.	2h 52m 44·10s		

In cases where extreme precision is required, these results may be corrected for second differences as in the last problem, the argument for the multiplier in this case being found at the bottom of the table given in the last problem.

Thus, reverting to the extract above given from the *Nautical Almanac* in the example under consideration, we have the sum of the right ascensions at 3h and 6h = 5h 46m 30·56s, and at 4h and 5h, 5h 46m 30·22s, half the difference of which is ·17s —, and for declination the second difference found in the same way is 3″·8.

Now in the above table the multiplier corresponding to 13m 46s, is about ·088, therefore ·17s × ·088 = 0·15s, the correction of R. A.; and 3″·8 × ·088, = ·3″ the correction of declination.

	h m s		° ′ ″
Approx. R. A. as above	2 52 44·10	Declin.	15 12 38·7
Cor. for second diff. ...	— ·015		+ ·3
From R. A.	2 52 44·085	Declin.	15 12 39

Examples for Exercise.

The right ascension and declination of the moon being given in the *Nautical Almanac* as under, for the corresponding hours of mean Greenwich time, viz.:

September 13th, 1835.

Hours.	☽'s Rt. Asc.	☽'s Declin.
	h m s	° ′ ″
0.	3 59 31·53	20 34 34·6 N
1.	4 1 32·77	20 42 59·1
2.	4 3 34·24	20 51 18·3
3.	4 5 35·93	20 59 32·1
4.	4 7 37·85	21 7 40·6
5.	4 9 39·99	21 15 43·6
6.	4 11 42·36	21 23 41·2
7.	4 13 47·79	21 39 19·6

It is required to find them accurately for each of the following Greenwich dates?

Answer.

	Greenwich Time. Sept. 13th.	Rt. Asc.	Declin.
	h m s	h m s	° ′ ″
1.	2 46 13	4 5 7·95	20 57 38 8
2.	4 20 50·6	4 8 20·23	21 10 28·6
3.	5 7 34·3	4 9 55·42	21 16 44·0
4.	6 42 9 8	4 13 8·47	21 29 13·8

Problem XVIII.

The noon's semidiameter and horizontal parallax being given for the noon and midnight of every day, mean Greenwich time, to find them for any given Greenwich date.

Take them from the *Nautical Almanac* for the noon or midnight next preceding the given date, and the change till the following noon or midnight. Multiply the change by the hours and decimals of an hour in the time past noon or midnight; divide the product by 12, and the quotient will be the correction to be applied to the value at the preceding noon or midnight, to obtain the value at the given time.

Example.

The moon's semidiameter and horizontal parallax being as under, per *Nautical Almanac*, it is required to find their value on October 3, 1835, at 16h 40m 12s, Greenwich mean time.

Oct. 1835.	☽'s Semidiameter.		☽'s Hor. Parallax.	
Day.	Noon.	Midnight.	Noon.	Midnight.
	′ ″	′ ″	′ ″	′ ″
1	15 41·8	15 37·2	57 36·2	57 19·4
2	15 32·7	15 28·4	57 2·9	56 46·9
3	15 24·1	15 19·9	56 31·2	56 15·8
4	15 15·8	15 11·9	56 0·8	55 46·4
5	15 8·1	15 4·4	55 32·4	55 19·1
6	15 1·0	14 57·8	55 6·4	54 54·6

16h 40m 12s is 4h 40m 12s = 4·67h past midnight; the semidiameter at midnight is 15′ 19″·9 − 4″·1, and the parallax at midnight 56′ 15″·8 − 15″. Hence $\frac{4''\cdot1 \times 4\cdot67}{12} = 1''\cdot6$ correction of semidiameter, and $\frac{15\text{s} \times 4\cdot67}{12} = 5''\cdot8$ correction of parallax. The semidiameter therefore, at the required time, is 15′ 19″·9 − 1″·6 = 15′ 18″·3, and the horizontal parallax 56′ 15″·8 − 5·8 = 56′ 10″.

Examples for Exercise.

Required the semidiameter and horizontal parallax of the moon at each of the following dates, Greenwich mean time.

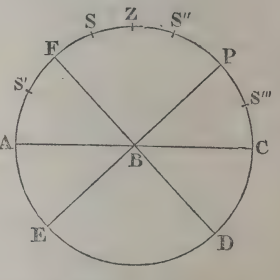
ANSWER.

		Semidiameter.	Hor. Parallax.
	h m	′ ″	′ ″
Oct. 2d, 1835	7 15	15 30·1	56 53·2
„ 4th „	19 24	15 9·6	55 37·8
„ 5th „	13 38	15 3·9	15 17·4
„ 1st „	4 51	15 39·9	57 29·4

In nautical astronomy the nearest second in the semidiameter and parallax may always be taken, and the decimals of an hour in the minutes and seconds of time need not be carried beyond the first place.

To deduce the latitude from the observed meridian altitude of a known celestial object.

If, in the annexed figure, A C be the intersection of the plane of the meridian and that of the rational horizon, and F D its intersection with the plane of the equator; and if Z be the zenith, P the north and E the south pole, and S the true place of a celestial object on the meridian; then S A is its meridian altitude, S Z its meridian zenith distance, and S F its north declination; and if S′ be the place of the object, S′ A is its altitude, S′ Z its zenith distance, and S′ F its south declination; if S″ be the place of the object, S″ C is its altitude, S″ Z its zenith distance, and S″ F its north declination.



Now Z S + S F, or S′ Z − S′ F, or S″ F − S″ Z = Z F the latitude.

Hence, for any object, from its observed find its true meridian altitude, and the complement of it is the meridian zenith distance; to be called north when the object is south, and south when the object is north, of the observer.

Find the Greenwich time of meridian passage by the preceding problems; and for that time find the object's declination.

Then if the zenith distance and declination be of the same name, that is, if they be both north or both south, their sum is the latitude; but if they be of different names their difference is the latitude, and it is always of the same name as the greater.

The declination of the sun, moon, planets, and principal fixed stars, are given in the *Nautical Almanac*, the sun's both for apparent and mean noon, the moon's for every hour, the planets' for every hour of mean Greenwich time, and those of the fixed stars' for the Greenwich time of meridian passage for every tenth day in the year.

The declination of the sun may be taken with sufficient exactness for practice at sea from Tables 19 and 20 of this book, and the declinations of the fixed stars from Table 23.

Note. It is perhaps difficult, under any circumstances, to obtain at sea an altitude that can be depended on to much nearer than a minute; it will therefore, in general, be sufficiently exact in sea practice to take the semidiameter and other corrections to the nearest minute; and, in finding the latitude at sea, the small corrections for the parallax of the sun and the planets may be safely disregarded.

Example I.

If the meridian altitude of ☉ be 56° 20′ 30″ S, on May 4th, 1845, in longitude 31° W, height of the eye 20 feet, required the latitude?

As the long is 31° W the Greenwich time is 2h. 4m. P. M., May 4		56° 20′ 30″ alt. ☉ S.
		+ 4 24 dip.
		56 16 6
		— 38 refraction.
		56 15 28
☉'s dec for noon, Greenwich time, May 4, 1825, Table 19	15° 57′ 37″	+ 15 52 semidiameter.
Reduction to 1845, Table 20	+ 2 33	56 31 20
		+ 5 parallax.
	16 00 10	
Cor for Green time, Table 30	+ 1 29	56 31 25 true altitude.
		90
True declination	16 1 39 N	33 28 35 zenith dist N.
		16 1 39 declination N.
		49 30 14 latitude N.

Example II.

On September 19th, 1823, in longitude 51° E, the meridian altitude of ♃ was 36° 52′ N, height of the eye 30 feet, required the latitude?

Per *Nautical Almanac*, (see Table 32,) ☽'s mer pass at Greenwich 11h 37m + 44m

Long in time E 3h 24m . . . Red Tab. 17 . . 6 . . .		3 30
Greenwich time		8 7
☽'s declination at 6h Greenwich time	0° 48′ 26″ S	
9h	0 6 41 S	
Change in 3 hours	0 41 45	prop log 6346
Time past 6 hours	2h 7m	1515
Change of ☽'s declination in 2h 7m	0° 29′ 27″	prop log 7861
Declination at 6 hours	0 48 26 S	
Declination at time of observation	0 18 59 S	disregarding second differences.

The horizontal parallax and semidiameter taken from the same Table, or from the *Nautical Almanac*, are 15′ 13″ and 55′ 49″.

Observed altitude ☽ . . .	36° 52′ 0″	N
Semidiameter 15′ 13″ } Aug . . . 9 } . .	+ 15 22	
	37 7 22	
Dip	— 5 24	
	37 1 58	
Correction, (Table 24,) . .	+ 43 18	
True altitude	37 45 16	
	90	
Zenith distance	52 14 44	S
Declination	0 18 59	S
Latitude	52 33 43	S

Example III.

If the meridian altitude of Rigel be 85° 6′ S, on November 25th, 1848, height of the eye 20 feet, required the latitude?

✳'s dec Jan. 1, 1820, (Table 23,) . .	8° 25′ 2″	S	Observed alt. 85° 6′ 0″ S
Annual var — 4″·74 × 28·9 years =	— 2 17		Dip . . 4 24
Declination at time of observation . .	8 22 45	S	85 1 36
			Refraction . 5
			85 1 31
			90 0 0
			Zenith dist. 4 58 29 N
			Declination 8 22 45 S
			Latitude . 3 24 16 S

Examples for Exercise.

In each of the following examples the latitude is required.

No.	Date.	Long. by Account.	Meridian Altitude.	Height of the Eye.	Latitude.
1	May 23, 1822	62° E	☉ 59° 14′ 22″ S	16ft.	51° 4′ 2″ N
2	May 1, 1823	47 W	☉ 69 30 16 S	14	35 15 5 N
3	Mar. 9, 1866	4 E	☉ 32 18 50 N	16	62 30 37 S
4	Aug. 5, 1822	45 W	☉ 26 5 47 N	13	46 40 17 S
5	Sept. 2, 1850	55 E	☉ 85 13 20 N	22	3 26 12 N
6	Nov. 14, 1823	163 W	☉ 21 36 25 S	12	49 59 1 N
7	July 26, 1841	13 W	☉ 16 14 34 N	18	54 42 0 S
8	May 8, 1872	105 W	☉ 76 3 16 N	10	3 35 16 N
9	Sept. 9, 1823	4 E	☉ 12 32 0 S	16	55 7 59 N
10	Sept. 11, 1823	160 E	☽ 19 43 0 S	13	43 59 45 N
11	Sept. 17, 1823	18 W	☽ 56 1 0 N	18	43 34 59 S
12	Sept. 21, 1823	0	☽ 81 12 0 N	12	2 51 43 N
13	Nov. 12, 1823		Marcab 45 48 40 S	9	58 30 47 N
14	May 23, 1835		Antares 55 26 17 N	13	60 41 26 S
15	Dec. 11, 1830		Capella 81 34 0 S	13	54 18 50 N
16	Nov. 5, 1826		Altair 57 2 30 S	18	41 27 24 N

To find the latitude from the observed altitude of a known celestial object when on the meridian below the pole.

In the last figure F P and Z C are quadrants, if therefore the common part Z P be omitted from each, P C, the elevation of the pole above the horizon, will be left equal to F Z the latitude. Hence if S‴ be an object on the meridian, below the pole, S‴ C its altitude, added to S‴ P the complement of its declination, will be equal to the latitude, and of the same name with the declination.

Now the sun is on the meridian below the pole 12 hours after noon, therefore if the longitude in time be added to or subtracted from 12 hours, according as it is west or east, the Greenwich time at which the sun will be below the pole will be obtained. If to the time of the moon's passing the meridian, determined by Problem 5, page 216, 12 hours, and half the daily difference of her meridian passage be added, the sum will be the time at which she will be below the pole; and, if 12 hours be added to the time at which a planet is on the meridian, the sum will be the time at which it is below the pole, exactly enough to compute its declination for finding the latitude at sea.

Let then the declination of the object be taken out for the instant of Greenwich time at which it passes the meridian below the pole, and to the complement of its declination add its true altitude, and the sum will be the latitude, of the same name with the declination.

Example.

If the altitude of ☉ on the meridian below the pole be 60° 26′, on July 4, 1822, longitude 21° W, height of the eye 18 feet, required the latitude?

	h m			
	12 0	☉'s declination at noon.	22° 56′ 5″ N	−5′ 17″
Long in time W	+ 1 24	Cor for Green time, Tab. 30	− 2 56	
Greenwich time	13 24	Reduced declination . .	22 53 9 N	
			90	
		Co-declination	67 6 51	
		Observed Altitude ☉	6° 26′ 0	
		Dip	− 4 11	
			6 21 49	
		Correction for parallax and refraction . .	− 7 54	
			6 13 55	
		Semidiameter	15 46	
		True altitude	6 29 41	
		Co-declination	67 6 51	
		Latitude	73 36 32 N	

Examples for Exercise.

In each of the following examples the latitude is required?

No.	Date.	Long. by Account.	Altitude below the Pole.	Height of the Eye.	Latitude.
1	June 16, 1846	18° E	☉ 16° 34′	15ft.	83°20′16″ N
2	May 4, 1868	35 W	☉ 9 28	20	83 16 14 N
3	Dec. 4, 1836	14 W	☉ 2 14	15	69 46 8 S
4	Aug. 13, 1850	42 W	☉ 3 18	14	78 44 14 N
5	Sept. 12, 1823	30 W	☽ 11 40	18	77 2 20 S
6	Sept. 24. 1823	140 E	♃ 4 50	20	70 43 18 N
7	Dec. 10, 1863		Vega 18 35	21	69 48 8 N
8	June 16, 1840		Capella 30 26	16	74 30 35 N
9	Nov. 20, 1857		Antares 14 18	12	78 4 10 S
10	April 5, 1871		Arcturus 8 40	17	78 38 37 N

To find the latitude from the altitude of the North Polar Star at any given time.

The distance of the pole star from the pole is so small, that the circle which it describes may, without material error, be considered as a plane, of which the pole is the centre, and the star's polar distance the radius. When the star is on the meridian above the pole, its altitude exceeds that of the pole, or the latitude of the place, by its polar distance; and, when it is on the meridian below the pole, its altitude is less than the latitude by the same quantity. When six hours distant from the meridian, its altitude is nearly the same as the altitude of the pole, and in nautical practice may be taken for it; in all other situations its polar distance may be considered as the hypothenuse of a right-angled plane triangle, of which the perpendicular is the difference between its altitude and that of the pole, and the acute angle included by those sides is the star's least distance from the meridian. To the apparent time at the place of observation add the sun's right ascension, and the sum is the sidereal time; from this subtract the star's right ascension, (increasing the sidereal time by 24 hours if necessary,) and the remainder is the star's *westerly* meridian distance.

Reduce this meridian distance into degrees, and, if less than 90°, consider it as a course; if between 90° and 270°, consider the difference between it and 180° as a course; and, if it exceed 270°, consider the difference between it and 360° as a course; with this course, and the star's polar distance in minutes as a distance, take from Tab. 2 the diff lat, and add it to the star's altitude when the meridian distance is between 6 and 18 hours; otherwise subtract it, and the sum or remainder is the latitude, always north.

Note. An error of a few minutes in the apparent time, or in the right ascension, will, in any case, produce but a trifling error in the result;

but the nearer the star is to the meridian, the less effect will any mistake in the time have on the latitude; and the right ascension may always be taken to the nearest minute.

Example.

If the altitude of the pole star be 46° 18′, at 9 h 26m P. M., October 7, 1836, in longitude 16° W, height of the eye 13 feet, required the latitude?

The Greenwich time of the observation is 10h 30m, and the sun's right ascension reduced to that time is about 12h 54m, the star's, 1h 1m, and its polar distance 94′.

Hence 9h 26m + 12h 54m − 1h 1m = 21h 19m = the star's meridian distance, and it is therefore above the pole. Now, 21h 19m = 320° nearly, and 360° − 320° = 40°, with which, as a course, and 94 as a distance, in Table 2, we have nearly 71′ in the latitude column to be subtracted from the star's true altitude.

Observed altitude	46° 18′	
Dip and refraction	4	
True altitude	46 14	
Correction, Table 2	− 1 11	
Latitude	45 3	N

Examples for Exercise.

In the following examples the latitude is required to the nearest minute?

No.	Date. Civil Time.	Long. by Account.	Hour, &c.	Alt. of the Pole Star.	Height of the Eye.	Latitude.
1	Dec. 11, 1850	25° W	4h 2m A.M.	28° 39′	12 ft	29° 21′ N
2	April 4, 1872	3 E	11 17 P.M.	56 2	16	57 17 N
3	July 5, 1863	31 W	8 40 P.M.	12 35	20	13 34 N
4	Aug. 26, 1850	42 W	3 31 A.M.	56 28	20	54 56 N
5	Sept. 14, 1828	36 W	10 0 P.M.	39 50	14	38 46 N
6	Nov. 20, 1825	2 E	1 14 A.M.	60 4	16	59 11 N

To compute the latitude from two altitudes of the sun, observed on a given day, and the time elapsed between the observations.

Find the time at Greenwich corresponding to the middle time between the observations, by Problem 4, page 215; reduce the sun's declination to that instant, and thence find his polar distance, by Problem 9, page 221. Compute the true altitudes by Problem 7,

page 218, and, if the ship has changed her place in the interval between the observations, the first altitude must be reduced to what it would have been if taken at the same place with the second. The correction for this purpose may be obtained thus: Take the angle included between the ship's course and the sun's bearing, at the first observation, as a course in Table 1 or Table 2, or the supplement of that angle, if it exceeds a right angle; and to the distance sailed in the interval, as a distance, the required correction will be found in the latitude column, being the minutes which the ship has sailed towards or from the sun. This correction must be *added* to the first altitude if *the angle is less than a right angle*, (in which case the ship will have sailed towards the sun,) and *subtracted if it is greater*, and the altitude will then be obtained which the sun would have had at the first observation, if it had been taken where the second was observed.

Having got the polar distance and the true altitudes reduced to the same place, take half the interval between the two observations, and, reducing it to degrees, call it the *half elapsed time;* and proceed to compute the latitude at the place of the second observation by the following rule.

1. Add the *sine* of the half elapsed time to the *sine* of the polar distance, and the sum, rejecting 10 from the index, will be the *sine* of *arc first*, which is always acute.

2. Add the *secant* of arc first to the *cosine* of the polar distance, and the sum, rejecting 10 from the index, will be the *cosine* of *arc second*, which will be *acute* or *obtuse*, like the *polar distance.*

3. Add together the *cosecant* of arc first, the *cosine* of half the sum of the true altitudes, and the *sine* of half their difference, and the sum, rejecting the tens from the index, will be the *sine* of *arc third*, acute.

4. Add together the *secant* of arc first, the *sine* of half the sum of the true altitudes, the *cosine* of half their difference, and the *secant* of arc third, and the sum, rejecting the tens from the index, will be the *cosine* of *arc fourth*, acute.

5. The difference of arc *second* and arc *fourth* is *arc fifth*, when the zenith and the elevated pole are on the same side of the great circle passing through the places of the sun at the times of observation; otherwise, their *sum* is *arc fifth*, acute.

6. Add the *cosine* of arc third to the *cosine* of arc fifth, and the sum, rejecting 10 from the index, will be the *sine* of the *latitude.*

Note 1. When there is any doubt whether the zenith and elevated pole are on the same side of the great circle passing through the places of the sun, the latitude may be computed on both suppositions, and that considered as the true latitude which most nearly agrees with

the latitude by account. This additional computation will give very little trouble, for it is only arc fifth and its cosine that will require alteration.

Note 2. By this method the latitude may be determined from two altitudes of the same fixed star, with the interval of time between the observations; but if the interval be in solar, it must be reduced to sidereal time, which may be done with sufficient exactness by increasing the observed interval one second of time for every six minutes, or ten seconds for every hour.

Note 3. It will expedite the calculation, if all the logarithms which are found at the same opening of the book be taken out at the same time; and any little mistake in the observations will produce a less error in the result, if the greater altitude be observed when the sun is not far distant from the meridian.

Example.

If on the 28th of February, 1868, in latitude by estimation 48° N, longitude 37° W, at 8h 9m 4s A. M., the altitude of ☉ be 27° 31′, bearing S ¼ E; and after running N E, 8 miles an hour, till 11h 30m 18s A. M. the altitude of ☉ be 32° 40′, height of the eye 20 feet, required the latitude at the time of taking the second observation?

As the angle between the sun's bearing and the course is 11¾ points, the ship has sailed within 4¼ points of the direction opposite to the sun; therefore, if the first altitude had been observed at the place at which the second was observed, it would have been less than it was observed to be by the distance which the ship has sailed directly from the sun. Now the distance run in the interval is nearly 27 miles, with which, as a distance, and 4¼ points as a course, in Table 1, we find in the latitude column 18′ for the correction of the first altitude, or the distance which the ship has sailed directly from the sun.

First alt ☉ . .	27° 31′ 0″		Second alt ☉	32° 40′ 0″	
Dip	— 4 24		Dip	— 4 24	
	27 26 36			32 35 36	
Cor of alt . . .	— 1 41		Cor of alt .	— 1 22	
	27 24 55			32 34 14	
Semidiameter .	+ 16 11		Semidiameter	+ 16 11	
True alt . . .	27 41 6			32 50 25	true altitudes.
Cor for ship's run	— 18 0			27 23 6	
Alt reduced to second place.	27 23 6		Sum of alts .	60 13 31	half sum 30° 6′ 45″
			Difference . .	5 27 19	half diff 2 43 39

Feb. 27, 20h	9m	4s	}	times of observation.
23	30	18		
Diff. . 3	21	14,		half diff 1h 40m 37s = 25° 9′, half elapsed time.
Sum . . 43	39	22,		half sum 21 49 41, middle time.
Longitude in time W			+ 2	28
Greenwich date at mid time . .			0 17	41 February 28

⊙'s declination, February 28, 1824, (per *Nautical Almanac*, or Table 19)			8° 14′	16″ S — 22′ 40″
Reduction to 1868, (Table 20)			— 7	51
			8 6	25
Correction for mid time at Greenwich, (Table 30) .			—	17
⊙'s corrected declination			8 6	8 S
			90	
Polar distance			98 6	8

To compute the latitude.

9·628378	sin	25° 9′	H.E.T.					
9·995646	sin	98 6	polar dist.	cos	9.148915			
9·624024	sin	24 53	arc 1,	sec	10·042313	. . . . .	cosec	10·375953
		98 56	arc 2,	cos	9·191228			
		. .		.	10·042313	sec arc 1.		
		. .			9·700498	sin	30° 7′ cos	9·937019
		. .			9·999506	cos	2 44 sin	8·678405
		. .			10·002103	sec arc 3.	5 38 sin	8·991377
							⋮ .. cos	9·997897
		56 17	arc 4.	cos	9·744420			
		42 39	arc 5.				cos	9·866586
						latitude N 47° 3′	sin	9·864483

Examples for Exercise.

The true latitude is required in each of the following examples, both altitudes being taken at the same place?

No	Date, Civil time.	Lat. by Acct.	Long. by Acct.	Hour, &c.	Altitude.	Height of the Eye.	True Latitude.
1	Sept. 2, 1823	° ′ 35 6 N	° 60 E	h m s 9 0 40 A.M. 1 0 25 P.M.	☉ ° ′ 35 30 ☉ 62 4	feet. 16	° ′ 34 57 N
2	April 20, 1824	49 3 N	20 W	7 41 35 A.M. 11 30 28 A.M.	☉ 19 4 ☉ 49 23	18	49 20 N
3	Nov. 22, 1822	45 16 S	20 W	2 50 16 P.M. 5 35 12 P.M.	☉ 46 16 ☉ 18 22	14	45 29 S
4	April 14, 1825	56 0 S	130 E	9 26 59 A.M. 1 12 59 P.M.	☉ 15 15 ☉ 23 4	17	56 32 S

By double altitudes of the same star.

No.	Date, Civil Time.	Lat. by Acct.	Object.	Hour, &c.	Altitude.	Height of the Eye.	True Latitude.
		°		h m s	° ′	feet.	° ′
5	July 12, 1823	33 N	Arcturus	9 25 17 P.M. 11 55 14 P.M.	53 28 22 16	17	33 21 N
6	Jan. 15, 1836 . . . 16, . . .	18 N	Sirius	10 30 0 P.M. 1 30 0 A.M.	55 7 35 57	15	18 20 N
7	Oct. 10, 1856.	44 15 N	Rigel	2 4 12 A.M. 6 7 30 A.M.	29 13 31 50	13	44 24 N

In each of the following examples the true latitude is required at the time of taking the second observation?

No.	Date, Civil Time.	Lat. by Acct.	Long. by Acct.	Hour, &c.	Altitude.	Bearing at first Observ.	Course, &c. in the Interval.	Height of the Eye.	True Lat.
		° ′	°	h m s	☉ ′			feet.	° ′
8	May 13, 1822	51 10 N	20 W	9 52 14 A.M. 2 12 20 P.M.	☉ 47 26 ☉ 48 13	S b E	S b E 4 miles per hour	20	51 28 N
9	Feb. 11, 1823	59 30 N	25 W	1 30 20 P.M. 3 33 25 P.M.	☉ 15 17 ☉ 6 30	S W	N E 10 miles per hour	15	59 16 N
10	Aug. 7, 1825	35 30 N	50 W	8 0 0 A.M. 1 0 0 P.M.	☉ 28 4 ☉ 69 10	E S E	N E ½ N 3·5 miles per hour	18	35 42 N
11	Dec. 21, 1824	42 0 N	18 W	9 30 0 A.M. 2 40 16 P.M.	☉ 20 12 ☉ 8 56	S b E ½ E	N W b W 6 miles per hour	20	42 14 N
12	Feb. 19, 1822	39 4 N	75 W	1 50 14 P.M. 4 0 14 P.M.	☉ 31 52 ☉ 12 58	S W b W	N W 5 miles per hour	17	39 39 N
13	Mar. 10, 1823	55 30 S	110 W	8 45 10 A.M. 0 30 16 P.M.	☉ 21 30 ☉ 39 1	N N E	N W b W 6 miles per hour	14	55 31 S
14	Mar. 29, 1823	68 12 S	20 E	8 30 0 A.M. 1 45 0 P.M.	☉ 7 56 ☉ 17 6	E N E	W ½ N 4 miles per hour	30	68 26 S

To compute the reduction to the meridian, and thence to find the latitude from an altitude observed when an object is near the meridian.

For the Greenwich time, by account, take the object's declination, and add it to the latitude by account, when they are of different names; otherwise, take the difference of the declination and the latitude by account, and the sum or the remainder is the meridian zenith distance by account.

If the object be the sun, the apparent time from noon is the meridian distance; *for any other object*, add the sun's right ascension to the apparent time, and from the sum subtract the object's right ascension, and the remainder is the meridian distance.

Then add together the cosine of the latitude by account, the cosine of the declination, the cosec of the meridian zenith distance by account, and twice the sine of half the meridian distance, in degrees, &c. and 5·615455, and the sum, rejecting the tens from the index, is the logarithm of a number of seconds, which subtracted from the true zenith distance, deduced from the observation, gives the meridian zenith distance. If this and the declination are of the same name, their *sum*, otherwise their *difference*, is the latitude, and of the same name with the greater.

Example.

If in latitude by account 48° 12′ N, when the sun's declination is 16° 10′ S, at 0h 16m P. M., apparent time, the sun's true zenith dist. be 64° 40′ N, required the true latitude?

Lat by acct	48° 12′ N.	cos	9·823821
Declination	16 10 S.	cos	9·982477
Mer zen dist acct	64 22	cosect	10·044995
Half mer dist.....	2 0	2 . sin	17·085638
		Const log	5·615455
	60) 357″	log	2·552386
	5′ 57″	reduction.	
	64° 40′ 0″	zen dist from obs.	
True mer zen dist	64 34 3	N.	
Declination	16 10 0	S.	
Latitude	48 24 3	N.	

Examples for Exercise.

In the following examples the latitude is required to the nearest minute?

No.	Date, Civil Time.	Lat. by Acct.	Long. by Acct.	App. Time.	Object.	Altitude	Height of the Eye.	Answer, Latitude.
		° ′	°	h m s			feet.	° ′
1	Aug. 7, 1824	40 55 N	38 W	11 38 10 A.M.	☉	65 1 S	14	40 42 N
2	May 5, 1825	29 14 S	16 E	0 24 20 P.M.	☉	44 1 N	17	29 11 S
3	Nov. 2, 1830	50 50 N	12 W	2 21 13 A.M.	Aldeb.	55 10 S	12	50 47 N
4	June 26, 1823	47 12 N	28 W	10 10 4 P.M.	Antares	16 40 S	20	47 23 N

Note. If, when the sun passes the meridian near the zenith, equal altitudes be taken a short time before and after his meridian passage, half the difference of the times may be taken as the meridian distance to be used with either altitude in computing the latitude by this problem.

ON FINDING THE VARIATION OF THE COMPASS BY CELESTIAL OBSERVATIONS.

If the bearing of a celestial object, as shown by a compass, be the same as the true bearing which the object is known to have at the same time, it is evident that the points of the compass are directed to the corresponding points of the horizon, and the compass has therefore no variation. If the compass show a bearing different from the known true bearing of the object, *that difference is the variation of the compass.* Thus, if an object bear E N E by a compass, at a time when its true bearing is E, the E N E point of the compass is directed to the E point of the horizon, and consequently every point of the compass is turned two points to the right of the corresponding point of the horizon, or the compass has two points easterly variation. But if an object should bear N W by a compass, at the time that its true bearing is known to be W N W, the N W point of the compass, to produce this effect, must be turned two points to the left, or the compass will have two points westerly variation.

We may hence infer, generally, that when the true bearing of any object is to the *left* of its bearing by the compass, the compass has *westerly*, and when to the *right*, it has *easterly* variation.

To find the variation of the compass by the bearing of a celestial object when on the meridian.

The sun is always on the meridian at apparent noon, and the time at which any other object will pass the meridian on any given day may be found by Problem 5, page 216. If, then, the error of the watch for apparent time be known, the time by it will be known when the object is on the true meridian, at which time the angle included between the magnetic meridian and the point on which the object bears, by the compass, will be the variation of the compass, *westerly* if the object is to the *right*, but *easterly* if it is to the *left* of the magnetic meridian.

For example, if an object on the meridian bear, by the compass, S 18° 40′ W, the variation is 18° 40′ W; if it bear N 14° E, the variation is 14° W; if it bear S 38° E, the variation is 38° E; if it bear N 21° W, the variation is 21° E.

To find the variation of the compass by the amplitude of the sun or a star.

From the effect of refraction, celestial objects appear on the horizon when they are 33′ below it, and therefore the altitude of the sun's centre, or the altitude of a star, should be about 33′ + the dip, when the amplitude is observed to find the variation; or the altitude of the sun's lower limb should be about 17′ + the dip.

To compute the true amplitude.

With the given time and longitude find the Greenwich time, and for that time take the object's declination; then to the sine of this declination add the secant of the latitude of the place of observation, and the sum, rejecting 10 from the index, will be the sine of the true amplitude, to be estimated from the *east* when the object is *rising*, and from the *west* when it is *setting;* and towards the *north* or *south*, according as the declination is *north* or *south*.

Then, if the computed amplitude and that by the compass be both north or both south, their difference will be the variation; but, if one be north and the other south, the sum will be the variation, *easterly* when the true amplitude is to the *right*, and *westerly* when it is to the *left* of the observed.

Example.

On January 24, 1822, at 6h 45m A. M., in latitude 21° 14′ N, longitude 31° W, the sun's rising amplitude was E 35° 20′ S; required the variation?

Astronomical time, January 23						18h 45m	
Longitude in time W						2 4	
Greenwich time						20 49	
☉'s declination at noon, January 23, 1822,			19°	30′	26″ S	− 14′	13″
Correction for 20h 49m (Table 30)			−	12	20		
Reduced declination			19	18	6 S	sin	9·519190
Latitude			21	14	0	sec	10·030531
True amplitude	E		20	46	0 S	sin	9·549721
Observed amplitude	E		35	20	0 S		
Variation			14	34	0 W		

Examples for Exercise.

In each of the following examples the variation of the compass is required?

No.	Date.	Latitude.	Long.	Hour, &c.	Object.	Observed Amp.	Variation.
		° ′	°	h m		° ′	° ′
1	April 29, 1824	35 22 N	12 W	5 32 A.M.	☉ rising	E 3 20 N	14 44 W
2	June 6, 1824	48 27 N	33 W	7 40 P.M.	☉ setting	W 14 23 N	21 15 E
3	Aug. 27, 1823	21 4 S	6 E	5 30 P.M.	☉ setting	W 10 0 N	0 57 E
4	Oct. 17, 1825	63 20 S	25 W	6 45 P.M.	☉ setting	W S W ½ W	4 26 W
5	June 21, 1822	29 32 N	21 W	5 30 A.M.	☉ rising	E 4 50 S	32 4 W
6	Jan. 25, 1826	16 21 S	15 W	11 0 P.M.	Spica rising	E 16 3 N	26 44 E
7	Jan. 3, 1830	38 17 S	25 E	5 0 P.M.	Sirius rising	E 16 20 S	4 51 E

The true amplitude may be found with sufficient exactness for nautical purposes by Gunter's scale, thus:—

Extend from the complement of the latitude to 90° on the line of sines, and that extent will reach towards the right on the same line, from the declination to the amplitude.

To find the variation of the compass by the azimuth of a known celestial object.

With the given time and longitude find the Greenwich time, (Problem 4, page 215,) and for that time take the declination of the object; find its polar distance, and compute its true altitude.

Add together the true altitude, the latitude, and the polar distance, and take the difference between half the sum and the polar distance; then add together the secant of the altitude, the secant of the latitude, (rejecting 10 from each of their indices,) the cosine of the half sum, and the cosine of the remainder, and half the sum of these four logarithms will be the sine of half the azimuth of the object, from the *south* in *north*, and from the *north* in *south* latitude; towards the east when the altitude is increasing, and towards the west when the altitude is decreasing.

Let the observed azimuth be estimated from the same point that the true azimuth is computed from; and if they are both east, or both west, their difference will be the variation; but if one is east, and the other west, their sum will be the variation; and easterly or westerly, according as the true azimuth is to the right or left of the observed one.

Example.

If on April 20, 1858, at about 9h A. M. the altitude of ☉ be 36° 50′ +, bearing S 31° E, in latitude 50° 12′ N, longitude 13° W, height of the eye 21 feet, required the variation?

Ship time, April 19	21h 0m	☉'s dec. April 19, 1822, .	11° 4′ 26″ N + 20′ 43″
Longitude in time, W +	52	Red. to 1858, (Table 20) .	+ 5 35
Greenwich time . .	21 52		11 10 1
		Cor for Green time, (Tab. 30)	+ 18 52
		Corrected declination . . .	11 28 53 N
			90
		Polar distance	78 31 7

Altitude ☉ . . .	36° 50′ 0″	Altitude . . .	37° 0′	sec 0·097651
Dip	− 4 31	Latitude . . .	50 12	sec 0·193746
	36 45 29	Polar distance .	78 31	
Correction	− 1 9		2)165 43	
	36 44 20			
Semidiameter . . .	+ 15 56	Half sum . .	82 51	cos 9·095056
True altitude . .	37 0 16	Remainder . .	4 20	cos 9·998757
				2)19·385210
		Half azimuth .	29 31	sin 9·692605
			2	
		True azimuth .	S 59 2 E	
		Observed azimuth	S 31 0 E	
		Variation . .	28 2 W	

Examples for Exercise.

In each of the following examples the variation is required?

No.	Date, Civil Time.	Hours, &c.	Lat.	Long.	Altitude.	Height of the Eye.	Observed Azimuth.	Var.
		h m	° ′	°	° ′	feet.		
1	May 17, 1824	2 0 P.M.	43 30 S	90 E	☉ 17 16 —	10	N	30 2 W
2	April 25, 1825	3 30 P.M.	63 14 N	10 W	☉ 29 46 —	17	S 78° 13′ W	21 51 W
3	Aug. 17, 1823	2 7 P.M.	59 27 N	174 W	☉ 38 50 —	13	S 41 2 W	0 46 W
4	Feb. 22, 1824	10 6 A.M.	53 15 N	42 W	☉ 21 50 +	14	S 1 5 W	30 51 W
5	March 5, 1824	10 0 P.M.	21 3 N	17 E	Spica 22 1 +	15	S E b S	35 9 W
6	Sept. 9, 1823	7 45 P.M.	20 4 N	154 E	☽ 16 50 —	23	S 46 24 W	13 4 E
7	Dec. 14, 1824	3 5 P.M.	44 2 S	45 W	☉ 42 8 —	11	W N W	14 36 W
8	Jan. 24, 1825	8 15 A.M.	26 5 S	0	☉ 38 24 +	8	E	4 32 E

The azimuth may be found with sufficient accuracy for nautical practice by Gunter's scale, as follows:—

Extend on the line of sines from the co. lat to the complement of the half sum in the above rule and examples, and that extent will reach, on the same line, and in the same direction, from the complement of the remainder to another point. Extend from this point to the co. alt, and that extent will reach from 90° to another point on the same line, and below that point, on the line of versed sines, is the supplement of the azimuth, reckoned, as above, from the N in south latitude, and from the S in north latitude.

On ship board, however, the direction of the needle is affected by the local attraction of the iron in the ship. If the iron is equally distributed, it produces no effect when the ship's head lies N or S by the compass, and the deviation is greatest when the head lies E or W. In ships of war, where the guns and other masses of iron present a large attracting surface, the effect of this local attraction on the needle is very considerable; it has been observed, in the channel, to amount to more than half a point.

The attention of men of science having been drawn to this phenomenon, Mr. Barlow, of the Royal Military Academy, at Woolwich, after various contrivances to determine its effect, with a view of *allowing* for it, at last devised a means of counteracting it. This device consists merely in placing a small iron plate in such a situation, behind the compass, and near to it, that the local action of the plate is an exact counterpoise to the effect of all the iron in the ship, whose centre of attraction is always before or forward from the place where the steering compass stands.

The proper situation for such a plate is easily found in harbour; for it is only necessary to lay the ship's head east or west, and to move the plate, behind the compass, upwards or downwards, nearer or farther off, till the bearing of a distant object, by the compass, is the same as its true known bearing, the plate then, in that as well as in every other situation of the ship's head, completely destroying the effect of the local attraction, while the position of the compass in the ship, and the situation of the iron in the ship, remain the same.

When the proper situation for the plate is found, it can be properly fixed and remain there. Many of his Majesty's ships have had such plates adapted to their compasses, and they have been found to answer completely.

ON THE PRINCIPLES OF THE METHODS OF FINDING THE LONGITUDE AT SEA BY CELESTIAL OBSERVATION.

As the longitude of any place is measured by the arc of the equator, or the angle at the pole, included between the meridian of that place and the first meridian; and the difference between the time at any place and that at the first meridian, is measured by a like arc of the celestial equator, or a like angle at the celestial pole, the longitude of any place would be known, if the mean, the sidereal, or the apparent time at the place, and at the first meridian, could be found at the same instant. Now, during the apparent diurnal revolution of the heavens, the distances of celestial objects from the horizon are continually varying, increasing from the time at which they rise till they pass the meridian,

and then decreasing in like manner till they set. Hence, at a given place, any proposed altitude of a known celestial object, eastward or westward of the meridian, corresponds to a determinate instant of time; and the time at any given place may therefore be inferred from the observed altitude of a known celestial object. But an altitude for determining the time should not be observed when the object is near the meridian, as the altitude then varies so slowly, that a small mistake in measuring it will produce a considerable error in the computed time; and the nearer the bearing of an object is to the east or west, the less effect will any mistake in measuring its altitude produce in the time computed from it.

Now, if a chronometer, keeping mean time, were set to the time at the first meridian, it would continue to show the time at that meridian to whatever place it might afterwards be carried; and therefore the difference between the time shown by such an instrument, and the mean time at any other meridian, determined by observation, or otherwise, *would be the longitude of that meridian in time*, twenty-four hours of time corresponding to the circumference of the equator, or to 360° of longitude.

The simplicity of this method of finding the longitude at sea, and the perfection to which the construction of chronometers has been brought, have combined to introduce it into very general practice, and its usefulness has been amply proved. But so delicate a machine as a chronometer must be peculiarly liable to be put out of order, even by causes which are difficult to detect and impossible to avoid; it is therefore desirable that, if possible, we should have some independent method of ascertaining the time at the first meridian.

Now, the moon revolves round the earth, or appears to revolve among the stars, from west to east, with an angular velocity so considerable, that the instant of time when she is at a given distance from a celestial object, lying in the direction of her motion, may be determined with considerable precision; and from the principles of Physical Astronomy, aided by observations, her place in the heavens can now be *predicted* with sufficient exactness for the practical purposes of navigation; and, in fact, in the Nautical Almanac, the distances of her centre from that of the sun, four of the planets, and some of the principal fixed stars that lie in the direction in which she moves, are given, and published for several years in advance, for every three hours of mean Greenwich time, except near the change, when she cannot be seen.

Hence, if an observer can determine by observation the moon's distance from the sun, or any of these stars, he may easily find the mean time at Greenwich, by comparing the observed distance with the distances given in the Nautical Almanac.

But the distances there given are those which would be seen at the

centre of the earth; and therefore, before any comparison can be instituted between them, and distances observed upon the surface, for the purpose of determining the Greenwich time, the distances observed on the surface must be reduced to what they would have been if seen at the centre. Now the places of celestial objects, as seen at the surface, differ from their places as seen from the centre by the effects of parallax and refraction, which vary with the altitude of the objects; the moon's place as seen from the centre being *above* and that of any other celestial object *below* its place as seen from the surface. (See page 213.)

Hence, before the true distance can be computed, the *altitudes* of the objects, as well as their *apparent distance*, must be known.

In practice, the altitudes and distances of the objects are generally measured at the same instant, by three different observers, while a fourth notes, by a watch, the times at which the observations are taken. Several sets of observations should, if possible, be taken, and a mean of the whole used as a single observation.

Such an observation is called a *lunar observation;* and this method of finding the longitude, by the distance of the moon from the sun or a star, is called *the method of finding the longitude by lunar observations.*

In altitudes used only for computing the true distance, no great precision is necessary; but an altitude for computing the time ought to be taken as exactly as possible. The greatest care, however, is required in measuring the distance, as an error of 1′ in it will generally produce an error of about 2m. of time, or of about half a degree in the longitude deduced from it. The distance of the nearest limbs of the sun and moon is always measured, and their semidiameters added to obtain the apparent distance of their centres. The distance of a star is measured from the round or enlightened edge or limb of the moon, whether that limb be the nearest to or farthest from the star; and the moon's semidiameter is added to the observed distance when it is measured from the nearest limb, but subtracted when from the farthest limb, to obtain the apparent distance of the star from the moon's centre.

A dexterous observer may himself obtain both the altitudes and distance, by taking the altitudes of the objects both before and after he measures the distance, noting the time of each observation, and then computing, by proportion, from the change of the altitudes, what they must have been at the time at which the distance was observed.

Various other methods have been proposed for finding the longitude by observation at sea, but none of them have yet been found capable of being reduced to practice, except perhaps the method of occultations, a simple mode of computing the longitude from which will be given in a subsequent part of this work. The methods of which we have here sketched the principles, are therefore those to which the attention of the practical mariner ought chiefly to be directed.

We may re-state that, to find the longitude, we must be able to do

two things which are perfectly distinct in themselves; viz., *to find the time at the place at which we are*, and *to find the time, at the same instant, at a place whose situation we know.* The former of these is found at sea from the observed altitudes of celestial objects, and the latter by the aid of a chronometer, or by the distance of the moon from the sun or a fixed star, from which her distance is computed in the Nautical Almanac.

When the apparent motion of a planet is contrary to that of the moon, the longitude can be more correctly deduced by a lunar distance from it, than by one from a fixed star; and, besides, Venus, Jupiter, Mars, and Saturn, (the planets whose distances from the moon are given,) can often be seen where there is daylight enough to take their altitudes with every requisite degree of exactness, either for clearing the distance or computing the time.

Altitudes can seldom be obtained at night at sea with sufficient exactness for computing the time; it will therefore be generally found preferable to find the error of the watch from altitudes of the sun during the day, and then to find the time at the ship at which a lunar distance is taken, by allowing for the error of the watch and the difference of longitude between the places where the altitude for the time and the lunar distance are measured. It will often, indeed, be found difficult to take altitudes at night with sufficient precision for the purpose of clearing the distance; but, as the time may be inferred from the altitudes of celestial objects, so, conversely, their altitudes may be inferred from the time; and it will often be found that, at sea, the altitudes of stars can be determined by computation with greater correctness than they can be observed. Having said this much by way of introduction, we proceed now to give, in order, the various practical problems connected with and subservient to the method of finding the longitude by observation by any method practicable at sea.

ON FINDING THE TIME.

To deduce the mean and apparent time at any place from the altitude of any known celestial object, when at a distance from the meridian on a given day; the latitude being known, and the longitude as well as the time at the place nearly.

Rule. With the supposed time and longitude find the Greenwich mean time by account, and for that time take from the Nautical Almanac the equation of time, and the declination of the object, and from the declination find the polar distance. If the object is not the sun,

take the sun's right ascension, and the object's right ascension, from the Nautical Almanac, and, having found the object's true altitude, proceed with the computation as follows. From half the sum of the object's true altitude, its polar distance, and the latitude of the place of observation, subtract the altitude.

Then add together the secant of the latitude, the cosecant of the polar distance, the cosine of the half sum, and the sine of the remainder, and the sum (rejecting the tens from the index) found in Table 5* will give the object's *westerly* meridian distance in time, to be taken from the top of the table when the altitude is decreasing, and from the bottom when increasing.

If the object is the sun, this meridian distance is the apparent time. If it is any other object, to the meridian distance add the object's right ascension, and the sum is the sidereal time. From the sidereal time subtract the sun's right ascension, and the remainder is the apparent time. To the apparent time apply the equation of time with the proper sign to reduce it to mean time.

The equation of time and the right ascension and declination of the sun and the principal fixed stars may be found, with sufficient exactness for practice at sea, from Tables 19 to 23.

If the altitude of the moon be used for finding time, her right ascension and declination *must* be taken from the Nautical Almanac, in which they are now given for every hour of mean Greenwich time. The right ascensions and declinations of the planets are given for every *noon*, as well as the distances of Venus, Mars, Jupiter, and Saturn, from the moon for every three hours of MEAN Greenwich time. Except for observations of the sun on the meridian, the Almanac must be entered with a *mean time Greenwich date.*

There are some small periodical corrections of the right ascensions and declinations of the fixed stars for the motion of light, and the effect of the attraction of the sun and moon on the position of the earth's axis, which corrections are not included in the places of the stars given in Table 23. But the true apparent right ascensions and declinations of 100 of the principal fixed stars, for every tenth day of the month, are now given in the Nautical Almanac; and, in deducing the error of a chronometer on land by altitudes taken from an artificial horizon, it will be proper to take the right ascensions and declinations from that table in the Nautical Almanac; but observations taken for finding time at *sea* admit of no such precision in their results as to render these minute corrections an object worth regard; the right ascensions and declinations in Table 23 being, for nautical purposes, sufficiently accurate.

Examples.

1. If on May 4th, 1840, at 7h 2m 50s A. M. by watch, in lat 37° 10′ N, long by acct 25° E, the altitude of ☉ be 21° 45′ +, height of the eye 14 feet, required the true apparent and mean time at that place?

19h 2m 50s	time by watch May 3rd.		
1 40 0	long in time E.		
17 22 50	Gr time by acct.		
Eq time May 3rd, 1824		3m 19s	+6
Red to 1840			1
		3	20
Cor for Gr time			4
True equation		3	24

☉ declin May 3rd, 1824,		
at noon Gr time	15° 44′ 30″	+17° 28″
Red to 1840, Tab. 20	2	5
	15 46 35	
Cor for Gr time, Tab. 30	12	39
True declin	15 59	14
	90	
Polar dist	74 0	46

Alt.	21° 54′ 56″		
Lat.	37 10 0	sec	10·098606
Pol dist.	74 0 46	cosec.	10·017131
	2)133 5 42		
	66 32 51	cos	9·599871
	44 37 55	sin	9·846677
App time	19h 2m 40s	Tab. 5*	9·562285
Equation	3 24	—	
Mean time	18 59 16		

21° 45′ 0″	observed alt.
3 41	dip.
21 41 19	
2 15	cor.
21 39 4	true alt ☉
15 52	semid.
21 54 56	alt ☉'s centre.

2. If on the 20th of February, 1863, at 9h 27m 4s P. M., the altitude of the star Menker be 13° 50′ decreasing, latitude 52° 30′ N, longitude 36° W, height of the eye 15; required the apparent and mean time?

9h 27m 4s	P M time by watch.		
2 24 0	W longitude in time.		
11 51 4	P M Green time.		

✲'s R A 1820	2h 52m 53s	+ 3·12s
Cor for 43 years	2 14	
✲'s R A for 1863	2 55 7	

☉'s R A Feb. 20, 1823,			
at noon, Green time	22h 12m 36s	+3m 50s.	
Red to 1863	1 13		
	22 13 49		
Cor for Green time.	1 54		
True right ascension.	22 15 43		

✲'s decl 1820.	3° 22′ 40″ N	+14·59s
Cor for 43 years	10 27	
✲'s decl 1863	3 33 7 N	
	90 0 0	
Polar distance	86 26 53	

True alt. . . .	13° 42′ 29″				Equa of time, Feb. 20, 1823, noon, Greenwich time .	14m 7s	Add. −7
Latitude. . . .	52 30 0	sec	·215553				
Polar dist. . . .	86 26 53	cosec	·000835		Red to 1863 (Table 20) .	— 3	
	2)152 39 22					14 4	
	76 19 41	cos	9·373578		Cor for Greenwich time .	— 3	
	62 37 12	sin	9·948401		True equation	14 1	
☼'s mer dist, Tab. 5*	4h 47m 56s		9·538367		Observed altitude . .	13° 50′ 0″	
☼'s R A	2 55 7					— 3 42	dip.
R A of mer.	7 43 3					13 46 18	
	24 0 0					— 3 49	ref.
	31 43 3				True altitude	13 42 29	
⊙'s R A	22 15 43						
App time	9 27 20						
Equation of time . .	14 1						
Mean time	9 41 21						

Examples for Exercise.

In each of the following examples, the apparent and mean times at the place of observation are required?

No.	Date, Civil Time.	Lat.	Long.	Time by Watch.	Object.	Altitude.	Height of the Eye.	Astronomical Time. Apparent	Astronomical Time. Mean.
		° ′	°	h m s		° ′	feet.	h m s	h m s
1	May 20, 1823	43 30 N	20 W	7 43 0 A.M.	☌	32 4 +	16	19 44 16	19 40 25
2	Aug. 10, 1824	54 12 N	25 W	5 33 0 P.M.	☋	16 50 —	18	5 32 39	5 37 38
3	June 9, 1825	15 18 N	40 W	7 42 18 A.M.	☌	29 40 +	22	19 45 29	19 44 13
4	Jan. 20, 1828	57 30 S	70 E	2 45 20 P.M.	☌	41 50 —	19	2 46 24	2 57 36
5	May 10, 1851	56 48 N	145 E	6 43 45 A.M.	☌	20 14 +	24	18 43 24	18 39 35
6	June 21, 1829	65 30 N	33 W	5 26 10 P.M.	☌	24 37 —	15	5 25 36	5 26 56
7	Feb. 8, 1837	40 36 S	20 E	4 28 3 P.M.	☋	27 46 —	9	4 25 49	4 40 21
8	Oct. 8, 1866	20 26 N	22 W	10 29 10 P.M.	Aldeb.	19 50 +	16	10 33 4	10 20 32
9	June 2, 1851	27 42 S	15 W	7 13 28 P.M.	Sirius	17 25 —	20	7 13 25	7 10 57
10	May 28, 1877	59 15 N	174 E	1 52 16 A.M.	Markab	21 25 +	13	13 50 23	13 47 13
11	Aug. 1, 1845	30 28 S	12 E	9 59 41 P.M.	Spica	11 15 —	12	10 2 12	10 8 8
12	Mar. 8, 1842	12 30 N	62 E	11 24 7 P.M.	Procyon	42 58 —	18	11 24 46	11 35 46
13	July 15, 1873	8 50 S	7 W	10 3 0 P.M.	Arcturus	29 48 —	20	10 4 34	10 10 11
14	Dec. 5, 1868	53 26 S	30 E	2 50 56 A.M.	Spica	11 26 +	24	14 50 30	14 41 25
15	Sept. 12, 1823	32 14 N	130 E	9 48 4 P.M.	♃	10 17 —	12	9 46 9	9 42 32
16	Sept. 16, 1823	19 30 S	61 E	4 57 15 P.M.	♃	29 3 +	13	4 57 29	4 52 28
17	Sept. 29, 1823	38 20 N	30 W	2 30 26 A.M.	♄	22 45 +	16	14 32 16	14 22 53

To find the error of a chronometer by equal altitudes of a fixed star.

Find the apparent time at which the star passes the meridian of the place of observation, by Prop. 5, page 216; and, by applying the equation of time, convert that time into mean time. The difference between this mean time and half the sum of the times shown by the chronometer, when on that day the star has equal altitudes, is the error of the chronometer for mean time at the place of observation;

fast, if the middle time by the chronometer is the greater, and slow if it is the less.

Example.

If, on October 11th, 1823, at Petersburgh, Altair have equal altitudes at 6h 12m 40s, and at 9h 28m 40s by a chronometer; what is its error for mean time at Petersburgh?

By Prob. 5, page 216, it appears that this star was on the meridian of Petersburgh at 6h 37m 27·6s, apparent time; and as the equation of time is then 13m 4·9s, subtractive, the corresponding mean time is 6h 24m 22·7s; the difference between which and 7h 50m 40s, the middle time by the chronometer, is 1h 26m 17·3s, the error of the chronometer, being *fast* for mean time.

Examples for Exercise.

Required the error of the chronometer for mean time at the place of observation in each of the following examples?

No.	Date. Civil Time.	Time of equal alts. by Chron.	Long.	Object.	Answer.
1	Oct. 5th, 1836 6	6h 30m 10s P.M. 1 1 40 A.M.	78° W	Marcab	11m 24s slow
2	Feb. 20th, 1840 Ditto.	7 4 12 P.M. 11 5 4 P.M.	40 E	Procyon	27 15 slow

To compute the equation of equal altitudes.

The equation of equal altitudes is a correction for the change of the sun's declination, to be applied to the middle time between the instants, by a chronometer, at which on a given day the sun has equal altitudes, to find the time by the chronometer when he is upon the meridian. It is, in fact, half the difference of the forenoon and afternoon hour angles when the sun on the same day has equal altitudes.

To compute this correction, take the logs A and B answering to the elapsed time from Table 18; and to each add the logs of the seconds in the change of the sun's declination, between the noon of the day preceding, and the noon of the day following the given one. And further add to log A the tangent of the latitude; and to log B, the cotangent of the sun's polar distance; and the sums, rejecting tens from the indices, are the logarithms of the two parts of the equation of equal altitudes. The first part, that under log A, is + when the polar distance is increasing, and − when it is decreasing; and the second part, that under log B, is − when the polar distance is acute and

increasing, or obtuse and decreasing; and + when the polar distance is obtuse and increasing, or acute and decreasing.

Note. The polar distance used in the computation may be taken, without reduction to the meridian, for the noon of the given day, Greenwich time.

Example.

On July 25, 1823, in latitude 54° 20′ N, at 8h 59m 4s A. M., and 3h 0m 40s P. M., the sun had equal altitudes; required the equation of equal altitudes?

	20h 59m 4s	⊙ declin July 24th	20° 1′ 4″ N
	27 0 40	26th	19 35 35 N
Interval .	6 1 36	Change in two days	25 29 = 1529″
		⊙ pol dist July 25th	70° 12′

To 6h 1 m 36s, in Tab. 18, we have,

Log A.	7·7707	Log B	7·6187
1529 log	3·1844		3·1844
Lat 54° 20′ tan	10·1441	Pol dist 70° 12′ cot . . .	9·5563
First part + 12·57 log . .	1·0992	Second part — 2·29 log. .	0·3594
−2·29			
+10·28 Equation of equal altitudes.			

Examples for Exercise.

In each of the following examples the equation of equal altitudes is required?

No.	Date.	Interval.	Latitude.	Equation of equal Altitudes.
		h m s	° ′	s
1	September 1, 1824	7 46 35	46 50 N	16·5 +
2	March 5, 1825	8 29 28	38 34 N	15·4 −
3	November 27, 1836	3 45 4	23 4 N	5·4 +
4	April 25, 1870	4 58 41	16 0 S	6·3 +
5	September 4, 1842	7 15 21	24 30 S	8·2 −
6	September 9, 1832	5 44 26	61 26 N	28·2 +

To find the error of a chronometer by equal altitudes of the sun.

Two or three hours before noon, let several altitudes of the sun's upper or lower limb be taken, noting the time of each observation by the chronometer, and again in the afternoon let the successive times by the chronometer be noted at which he arrives at the same altitudes. Take the mean of the times at each set of observations, adding 24 hours to the mean of those in the afternoon, and half the sum of these

means will be the middle time between the observations, and the difference of them will be the elapsed interval of time. With this interval, the latitude, polar distance, and change of declination, compute the equation of equal altitudes, as in the last problem, and apply it, with the proper sign, to the middle time; and the result will be the time shown by the chronometer at apparent noon; and the difference between that time and 24 hours will be the error of the chronometer for apparent time at the place of observation.

To find its error for mean time, either at the place of observation or at Greenwich, reduce the equation of time to the given meridian, (see the use of Table 22,) and add it to, or subtract it from, 24 hours, as directed in the Nautical Almanac, or Table 22, and the result will be the *mean time* when it is apparent noon at the place of observation; to which apply the longitude of the place in time, adding it if west, and subtracting it if east, and the mean time at Greenwich when it is apparent noon at the given place will be obtained. Hence the difference between the middle time, corrected as above for the equation of equal altitudes, and the mean time at the place when it is apparent noon, will be the error of the chronometer for mean time at the place of observation; and the difference between the corrected middle time and the corresponding mean time at Greenwich will be the error of the chronometer for Greenwich mean time.

Example.

On July 25, 1823, in latitude 54° 20′ N, longitude 20° 30′ E, equal altitudes of ☉ were observed, as under; required the error of the chronometer for apparent and mean time at the place of observation, and also for mean time at Greenwich?

											Add.
	8h	58m	30s	A.M.	31°	30′	☉	3h	1m	15s	P.M.
		58	47			35			0	56	
		59	4			40			0	40	
		59	21			45			0	23	
		59	38			50			0	6	
Mean	8	59	4					3	0	40	
	12							24			
Mean	20	59	4					27	0	40	
times	27	0	40								
Sum. .	47	59	44	half sum 23h 59m 52s mid time.							
Diff. .	6	1	36								

Equation of time	0h	6m	7s + 1s
Cor for long . .	0	0	0
Reduced equa. .	0	6	7
Time of ap noon	24	0	0
Mean time at do.	24	6	7
Long in time E	1	22	0
Mean T. at Gr.	22	44	7

The equation of equal altitudes (see the last problem) is about 10s to be added to the middle time. Hence 23h 59m 52s + 10s = 24h 0m 2s, the time by the chronometer at apparent noon.

Time by chronometer at apparent noon	24h 0m 2s
Time of apparent noon.	24 0 0
Mean time at apparent noon.	24 6 7
Corresponding Greenwich mean time	22 44 7
Chronometer fast for apparent time at place of observ.	2
Chronometer slow for mean time at place of observ. .	6 5
Chronometer fast for mean time at Greenwich. . . .	1 15 55

Examples for Exercise.

In the following examples the error of the chronometer for mean time at *Greenwich* is required, the sun having in each case equal altitudes at the times marked A. M. and P. M.?

No.	Date.	Times of equal Altitudes.		Lat.	Long.	Error of Chron. for Green Time.
		h m s	h m s	o ′	o ′	h m s
1	Sept. 1, 1824	8 7 29 A.M.	3 54 4 P.M.	46 50 N	32 7 E	2 9 40 fast.
2	Mar. 5, 1825	7 45 21	4 14 49	38 34 N	59 30 W	4 9 55 slow.
3	Apr. 17, 1822	9 15 43	2 45 0	32 18 N	55 50 W	3 42 39 slow.
4	Nov. 27, 1836	10 7 22	1 52 26	23 4 N	16 4 W	0 52 17 slow.
5	Jan. 12, 1849	8 28 26	3 31 12	8 56 N	51 14 E	3 15 59 fast.
6	Apr. 25, 1870	9 30 35	2 29 16	16 0 S	13 0 E	0 54 11 fast.
7	Sept. 4, 1842	8 22 18	3 37 39	24 30 S	47 0 W	3 7 6 slow.
8	Sept. 9, 1832	9 7 42	2 52 8	61 26 N	22 0 E	1 31 13·9 fst.

To find the rate of a chronometer.

The rate of a chronometer, or its daily gain or loss, is determined by comparing its errors for mean time, as found by observation at a given place on different days, either by the altitude of the sun or a star, or by equal altitudes of the sun or a star, as shown in the preceding problems. Thus if by observation a chronometer is found 20s fast, and at the end of ten days 30s slow for mean time at the same place, it has evidently lost 50s in ten days; whence its daily rate is 5s *losing*. If on a given day a chronometer be 12s fast, and at the end of thirteen days 57s fast for mean time at any place, it must have gained 45s in thirteen days, or its rate is about 3·5s per day *gaining*. Hence the method of finding the rate of a chronometer is evident.

When the longitude of a place at which observations are taken for the error of a chronometer is accurately known, it will be found convenient in all cases to find its error for Greenwich time, which may be done by finding (Problem 4, page 215) the time at Greenwich corresponding to the time at the given place as computed from observation, and comparing that time with the time shown by the chronometer. When the errors are all referred to Greenwich time, the rate can easily be found from observations taken at different places; and it is often desirable to do this; for a seaman cannot always stop long enough at one place to obtain a rate that is entitled to confidence; as the unavoid-

able errors of any observation render it advisable that a rate should not be deduced from observations separated from each other by a very short interval of time. If more than two sets of observations can be obtained, it will be seen from the results whether the rate of the chronometer is uniform or not; and for this purpose the mariner should lose no opportunity to multiply observations, that any change in the rate may be detected and allowed for.

The student, if acquainted with the preceding problems, will, from what has been said, experience no difficulty in finding the rate in each of the following examples, or indeed in any case that can arise in practice.

Examples for Exercise.

It is required, from the observed altitudes of the sun, to find the error of the chronometer for mean time at Greenwich, and its rate, in each of the following examples?

No.	Date.	Time by Chronometer.	Place of Observation.	Observed Altitude.	Height of the Eye	Er. of Chro. for Green T.	Rate.	Man.
		h m s		° ′	feet.	h m s	s	s
1	April 14,1822	7 33 45 A.M.	Copenhagen	☉ 26 4 +	14	0 8 30 fast	·2+	
	May 3,1822	7 29 4 A.M.	Copenhagen	☉ 31 14 +	14	0 8 33 fast		
2	July 7,1823	7 43 4 A.M.	Plymouth	☉ 30 5 +	16	0 0 0	·5+	
	Aug. 24, 1823	7 55 3 A.M.	Plymouth	☉ 24 18 +	16	0 0 24 fast		
3	Oct. 16, 1824	11 58 28 P.M.	Batavia	☉ 21 4 +	20	0 0 18 fast	1·2−	
	Dec. 20, 1824	11 52 18 P.M.	Batavia	☉ 16 37 +	20	0 1 3 slow		
4	July 29, 1824	8 15 11 P.M.	Quebec	☉ 36 14	20	0 20 34 slow	·8+	1.0+
	Aug. 8, 1824	8 46 35 P.M.	Quebec	☉ 28 57	20	0 20 28 slow	1·2+	
	Aug. 18, 1824	8 46 9 P.M.	Quebec	☉ 26 34	20	0 20 15 slow		
5	April 10,1823	7 0 20 P.M.	Buenos Ayres	☉ 26 41 −	Artif.	0 12 18 slow	16·3+	
	May 5, 1823	5 33 0 P.M.	Rio Janeiro	☉ 32 52 −	Horiz.	0 5 29 slow		

In each of the following examples it is required to find the error of the chronometer for mean time at Greenwich, and its rate, from the times at which the sun had equal altitudes?

No.	Date.	Times of equal Alts. by Chronometer.	Place of Observation.	Error of Chronom. for Green. Time.	Rate.
		h m s		h m s	
1	May 4, 1824	9 57 45 A.M. 3 16 17 P.M.	Gibraltar	0 18 52 fast	35·7−
	May 18, 1824	9 21 38 A.M. 3 34 50 P.M.	Gibraltar	0 10 36 fast	
2	Aug. 14, 1822	10 14 16 A.M. 4 10 24 P.M.	Funchal	0 0 7 fast	·08+
	Nov. 5, 1822	8 49 54 A.M. 0 43 32 P.M.	Naples	0 0 14 fast	
3	June 11, 1823	7 58 17 A.M. 1 48 28 P.M.	Riga	0 30 48 fast	7·8−
	Aug. 1, 1823	10 53 9 A.M. 3 13 3 P.M.	Cork	0 24 10 fast	

In each of the following examples it is required to find the error of the chronometer for mean time at Greenwich, and its rate, from the times at which the same star had equal altitudes?

No.	Date.	Times of equal Alts. by Chronometer.	Place of Observation.	Object observed.	Er. of Chron. for Green. Time.	Rate.
		h m s			m s	
1	April 10, 1824	6 14 12 P.M.	La Valette	Regulus	38 10 fast	1·2+
		10 32 16 P.M.	In Malta			
	May 14, 1824	7 50 16 P.M.	Ditto	Spica	38 52 fast	
		11 3 4 P.M.				
2	Oct. 12, 1825	9 0 50 P.M.	Oporto	Algenib	0 4 slow	1·3+
	Oct. 13, 1825	1 26 40 A.M.				
	Nov. 1, 1825	6 1 5 P.M.	Plymouth	Marcab	0 22 fast	
		10 58 11 P.M.				

Note. In the above rates + signifies *gaining*, and — *losing*.

To find the rate of the chronometer without reference to its error, by equal altitudes of the same fixed star, observed at the same place, and on the same side of the meridian, on different nights.

Divide the difference of the times of equal altitudes as observed on different nights, by the number of days elapsed, and the difference between the quotient and 3m 55·91s is the *rate*, gaining when the quotient is less, and losing when it is greater than 3m 55·91s.

EXAMPLE.

On May 4th, at 10h 15m 26s, and on May 12th, at 9h 43m 38s, a star, on the same side of the meridian, had equal altitudes, required the rate of the chronometer?

	h m s	
Time of 1st observation	10 15 26	
2d do. . . .	9 43 38	
No. of days	8)31 48	diff.
	3 58·5	
	3 55·91	
Rate losing	2·59	

The nearer the object, whose altitude is observed, is to the prime vertical, the better; and that the changes in the refraction may not sensibly affect the result, it is desirable that the altitude should not be less than 8 or 10 degrees.

Examples for Exercise.

No.	Date.	Time of equal Alts.	Rate.
		h m s	s
1	Oct. 5	8 4 3	9·9+
	Oct. 19	7 11 19	
2	March 3	10 11 25	2·1−
	March 8	9 51 35	

TO FIND THE LONGITUDE BY A CHRONOMETER.

Let an altitude of the sun, the moon, or a star, be taken when the object is at a considerable distance from the meridian; or, rather, let a series of altitudes be taken, at short intervals of time, and take the mean of the altitudes, and also of their corresponding times;—to the mean of the times apply the last known error of the chronometer, adding, if it is slow, and subtracting, if fast; multiply the rate by the number of days and parts of days that have elapsed since the last error was determined, and add the product to the above corrected time, if the chronometer is losing, but subtract it if gaining. To the sum or remainder apply the longitude of the place for which the error was found, by addition or subtraction, according as the longitude is west or east, and the *mean* time at Greenwich will be obtained. For that instant take the data requisite for computing time from the Nautical Almanac, or the tables in this book. With the latitude of the place, the altitude and polar distance of the object, compute its meridian distance, and thence find the apparent time at the place of observation, and by applying the equation of time reduce that apparent time to *mean time*, the difference between which and the Greenwich mean time, found as above from the chronometer, is the longitude of the place in time, west if the Greenwich time is *before*, but east if the Greenwich time is *behind*, the ship time.

Example.

If on March 4, 1822, a chronometer be 2m 40s slow, and on April 7, 1m 5s fast for mean time at Greenwich; and if on July 14, at 7h 3m 5s, by the same chronometer, the altitude of ☉ be 20° 34′ −, in latitude 31° 28′ N; height of the eye 18 feet, required the longitude?

March 4, chronometer slow 2m 40s
April 7, chronometer fast 1 5
Gain in 34 days . . . . . 3 45, and $\frac{3\text{m } 45\text{s}}{34} = 6{\cdot}6\text{s}$, the daily rate, *gaining*.

From April 7 to July 14 there are 98 days, hence 6·6s × 98 = 10m 47s, the gain of the chronometer since April 7.

Time per chronometer .	7h 3m 5s	⊙'s dec. July 14, 1822,	
Chron. fast April 7 . . .	— 1 5	(Naut. Alm. or Tab. 19,)	21° 45′ 40″ N — 9′ 9″
	7 2 0	Cor. for Greenwich time .	— 2 35
Gain from the rate. . .	— 10 47	Reduced declination . .	21 43 5
Mean time at Greenwich	6 51 13		90
		Polar distance	68 16 55

Add to app.

Equa. of time, July 14, 1822	5m 23 + 7
Cor. for Greenwich time. .	2
Reduced equation	5 25

Observed alt. of ⊙	20° 34′ 0″	Altitude . .	20° 43′ 38″	
Semidiameter . .	+ 16 9	Latitude . .	31 28 0 sec	·069079
	20 50 9	Polar dist. .	68 16 55 cosec	·031977
Dip.	— 4 11		2) 120 28 33	
	20 45 58		60 14 17 cos	9·695830
Correction	— 2 20		39 30 39 sin	9·803610
True altitude. . .	20 43 38	App. time at ship, Tab. 5,	5h 13m 11s	9·600496

Equat. time add.	5 25	
Mean time at ship. .	5 18 36	
Do. at Greenwich . .	6 51 13	
Long. in time W. . .	1 32 37	= 23° 9¼′

Examples for Exercise.

1. If my chronometer be 5h 3m 20s *fast* for mean time at Quebec, on June 24, 1881, and gaining 12s per day; and on August 26, at 7h 2m 20s P. M. by the chronometer, the altitude of Marcab be 16° 40′ increasing, in latitude 50° 2′ N, height of the eye 15 feet, required the longitude? Answer, 10° 17′ 45″ east.

2. If, on February 11, 1825, my chronometer be 48m 37s *fast*, and on March 4, 46m 23s *fast* for Greenwich mean time; and if, on April 18, in latitude 18° 24′ N, at 7h 2m 40s A. M. by the chronometer, the altitude of ⊙ be 11° 26′ +, height of the eye 15 feet, required the longitude? Answer, 3° 20′ east.

3. If, on November 2, 1824, my chronometer be 23m 40s *fast*, and on November 18, it be 21m 56s *fast* for mean time at Portsmouth; and on December 21, in latitude 37° 28′ N, at 2h 40m 10s A. M., the altitude of Altair be 32° 56′ —, height of the eye 17 feet, required the longitude? Answer, 135° 49′ 15″ west.

4. If, on May 4, 1838, I find my chronometer 1h 30m *slow* for mean time at Cape Town, and on May 29, 5m 37s *slow* for mean time

at James Town, St. Helena, and in latitude 14° 20′ N, on my voyage homeward, on July 10, at 6h 30m 20s P. M. by the chronometer, the altitude of ☉ be 38° 20′ −, height of the eye 26 feet, required the longitude? Answer, 54° 40′ 45″ west.

5. If, on May 4, 1868, my chronometer be 1h 2m 36s *slow*, and on June 15, 1h 4m 40s *slow* for mean time at Cork; and if farther, on July 10, at 7h 2m 30s P. M. by the same chronometer, the altitude of Antares be 34° 12′ −, in latitude 14° 26′ N, height of the eye 26 feet, required the longitude? Answer, 45° 28′ east.

6. On July 5, 1822, my chronometer was found to be 1h 12m 46s *fast* for Greenwich mean time, and gaining 10s per day; and on October 10, in latitude 35° 12′ S, at 6h 40m 8s A. M. by the chronometer, the altitude of ☉ was 14° 26′ +, height of the eye 13 feet, required the longitude? Answer, 22° 20′ 30″ east.

7. If a chronometer be 40m 26s *fast* for mean time at Portsmouth, on May 4, 1823; and on arriving at Funchal, on June 2, it be found 1h 37m 55s *fast* for mean time at that place; what will be my longitude if, on August 24, in latitude 38° 4′ S, at 0h 14m 45s P. M. by the chronometer, the altitude of ☉ be 23° 4′ 50″ +, height of the eye 30 feet? Answer, 48° 0′ 45″ west.

8. On May 3, 1822, my chronometer was 10m 30s *fast* for mean time at Yarmouth, longitude 1° 44′ E, and losing 4·7s per day; on June 17, at noon, I was in latitude 38° 14′ N, and after running S W ½ W 38 miles, I found the altitude of ☉ to be 20° 40′ −, at 9h 26m 14s by the chronometer, height of the eye 30 feet, required the latitude and longitude?

Answer, latitude 37° 50′ N, and longitude 56° 49′ 15″ west.

ON COMPUTING ALTITUDES.

To compute the true and apparent altitude of any celestial object.

If the object be the sun, and the time P. M., the apparent time is the meridian distance; but if the object be the moon or a star, to the apparent time add the sun's right ascension for the given instant, and the difference between the sum and the right ascension of the object at the same instant, is the meridian distance of the object.

Reduce the meridian distance into degrees, &c., take the object's polar distance and the colatitude of the place of observation; and to compute the true altitude, proceed as follows.

Add together, twice the sine of half the meridian distance, the sine of the polar distance, the sine of the colatitude, and twice the secant of half the difference of the polar distance and the colatitude, and reject-

ing 40 from the sum, half the result is the sine of arc 1. Add the cosine of arc 1 to the cosine of half the difference of the polar distance and colatitude, and the sum, rejecting 10, is the sine of arc 2. Double arc 2, and rejecting 90°, you have the true altitude.

To the true altitude add the correction of altitude, if the object be the sun or a star; but subtract the correction from the true altitude if the object be the moon, and the sum or remainder is the apparent altitude *nearly*.

Take, again, the correction corresponding to this apparent altitude, and apply it as before to the true altitude, and the result will give the apparent altitude still more nearly. The correction to this last altitude may be taken again, and applied to the true altitude as before, but this will scarcely, in any case, be necessary.

Note. If the *mean time* at the place of observation is given, it must be converted into *apparent* time, before it is used in finding the meridian distance.

Examples.

On September 11, 1823, at 3h 7m 2s P. M., apparent time, in lat 38° 14′ S, long about 20° W, I took a lunar distance, but I could not observe the moon's altitude; it is required to determine the altitude by calculation?

				⊙'s R. A. noon.	
3h	7m	2s	apparent time at the ship, Sept. 11.	11h 15m 53s	+ 3m 35s
1	20	0	longitude in time W.		40 Cor.
4	27	2	Greenwich time.	11 16 33	⊙'s R. A.

☽'s R. A. at 3h.			☽'s declin. at 3h.		☽'s hor. par.	
16h 34m 20s	+ 6m 43s	cor.	25° 43′ 25″ S	+ 7′ cor.	54′ 58″	− 15″ cor.
16 37 34·7			25 46 47		54 53	
			90			
			☽'s pol. dist.	64 13 13		

App. time . .	3h	7m	2s
⊙'s R. A. . .	11	16	33
Sid. time . .	14	23	35
☽'s R. A. . .	16	37	34·7
☽'s mer. dist.	2	13	59·7 = 33° 30′

Half mer. dist.	16° 45′	2 sin	18·919376	
☽'s pol. dist.	64 13	sin	9·954457	
Colat.	51 46	sin	9·895145	
Diff.	12 27			
Half diff. . .	6 13½	2 sec	20·005136	cos 9·997432
		2)	18·774114	
Arc 1. .	14° 7′	sin	9·387057	cos 9·986683
Arc 2 . .	74° 36′			sin 9·984115
	2			
Less 90°	59 12	True alt.		
Approximate cor. .	28			
App. alt. nearly . .	58 44			
True cor.	27 54			
Correct app. alt. . .	58 44 6			

Examples for Exercise.

In the following examples the apparent altitude is required to the nearest minute?

No.	Date, Civil Time.	Hour, &c. Appar. Time.	Latitude.	Long. by Acct.	Object.	Answer, Appar. Alt.
		h m s	° ′	°		° ′
1	Feb. 9, 1823	2 10 22 P.M.	55 10 N	16 W	☉	14 53
2	Oct. 17, 1826	9 40 36 A.M.	48 3 N	160 W	☉	24 57
3	April 4, 1825	4 3 28 P.M.	21 50 S	59 E	☉	24 25
4	Oct. 29, 1841	5 32 13 A.M.	42 12 S	0	☉	4 8
5	Aug. 24, 1822	2 7 22 A.M.	63 17 N	1½ E	Altair	17 3
6	Oct. 11, 1823	11 30 16 P.M.	50 11 N	14 W	Pollux	13 1
7	May 17, 1825	2 45 38 A.M.	29 46 S	125 E	Antares	63 23
8	Mar. 28, 1824	10 15 36 P.M.	48 21 N	27 W	Arcturus	40 53

To find the altitudes when a lunar distance is taken, from altitudes before and after taking the distance.

If in taking lunars there be only one observer, let him take the altitude of each object both before and after taking the distance, noting by his watch the time of each observation. Then to find the altitude of either object at the time of taking the distance,—add together the comp to 10 of the prop log of the interval between taking the altitudes of that object, the prop log of the interval between taking the first altitude and the distance, and the prop log of the observed change of altitude, and the sum, rejecting 10 from the index, will be the prop log of a correction, to be added to the first altitude when it is increasing, but subtracted from it when decreasing, to obtain the altitude of the object at the time of taking the distance.

Example.

Time by Watch. h	m	s		°	′	″
4	10	10	☽'s alt	34	12	10
4	12	26	☉'s alt	57	16	40
4	15	29	dist ☉ and ☾	80	34	20
4	17	29	☉'s alt	56	50	20
4	19	40	☽'s alt	34	50	30

Req the alts at 4 15 29 when the distance was taken?

	Moon. m	s		Sun. m	s	
Int. of alts . . .	9	30	P. log comp 8·7225	5	3	8·4480
First alt to dist . .	5	19	P. log 1·5296	3	3	1·7710
Change of alt. . +	38′	20″	P. log 6717	− 26′	20″	8348
Red of alt . . . +	21′	27″	P. log 9238	− 15′	54″	P. log 1·0538
☽'s first alt . . .	34°	12	10	57°	16	40
☽'s alt at time of dist	34	33	37	☉'s alt 57	0	46

Examples for Exercise.

Required the altitudes at the time of taking the distance in each of the following examples?

Time by Watch. h	m	s					Answer.			
Ex. 1. 9	27	34	Marcab's alt	21°	19′	30″	☽'s alt	48°	19′	1″
9	28	47	☽'s alt	48	40	10	✲'s alt	21	32	52
9	31	2	dist ☽ and ✲	37	29	25				
9	33	14	☽'s alt	47	58	20				
9	35	8	Marcab's alt	21	48	40				
h	m	s								
Ex. 2. 15	38	17	☽'s alt	30	10	0	☽'s alt	30°	34′	23″
15	40	25	Aldeb alt	60	25	0	✲'s alt	60	38	53
15	42	16	dist ☽ and ✲	48	12	30				
15	44	0	☽'s alt	30	45	0				
15	45	37	Aldeb alt	61	4	0				

ON CLEARING THE LUNAR DISTANCE.

Having given the apparent altitudes of the centres of the moon and the sun, or a star, with their apparent distance, and horizontal parallaxes, to find their true distance, as seen at the centre of the earth.

Method I.

With the moon's apparent altitude and horizontal parallax; enter Table 24, and take out the correction of her altitude; and at the same

time, from Table 25, on the opposite page, take out the auxiliary arc, adding the correction of that arc taken from the column on the right of the table, if the other object is the sun or a fixed star, but from Table 27 if the other object is a planet.

The refraction (Table 9) corresponding to a star's apparent altitude is its correction of altitude, but the difference of the parallax in altitude and the refraction is the correction of altitude of the sun or a planet. Now the sun's parallax in altitude is found in Table 10, and that of a planet may be taken from Table 26.

Add the difference between the correction of the moon's altitude and that of the sun or star, to the sum of the apparent altitudes, and the result is the sum of the true altitudes.

Then place under each other, in order, the sum of the apparent altitudes, the auxiliary arc, and the apparent distance, under which draw a line, and below this line place, also in order, the sum and difference of the auxiliary arc and the sum of the apparent altitudes, and the sum and difference of the auxiliary arc and the apparent distance, and under all write the sum of the true altitudes, making altogether five arcs.

Then, from Table 28, take the *decimal versed sine* of the first four of these arcs, and the *decimal suversed sine* of the last one; add them together, and the sum, rejecting the tens from the sum of the digits, on the left, will be the *decimal versed sine* of the true distance, which will be found (and must be sought for only) in the column corresponding to the apparent distance, or in one of those immediately adjoining to it.

Method II.

Take the moon's correction of altitude, the auxiliary arc, and the sun or the star's correction of altitude, as in Method I.

Then add the sum of the corrections of altitude to the difference of the apparent altitudes, if the moon's altitude is the greater, but take their difference when the moon's altitude is the less, and the sum or the remainder will be the difference of the true altitudes.

Then place under each other, in order, the difference of the apparent altitudes, the auxiliary arc, and the apparent distance, under which draw a line; and below this line place, also in order, the sum and difference of the auxiliary arc, and each of the two others, as in Method I., and under all write the difference of the true altitudes, making altogether five arcs.

Then take from Table 28, and add together, the *decimal suversed sine* of the first two of these arcs, and the *decimal versed sine* of the last three, and the sum, rejecting the tens from the sum of the digits on the left, will be the *decimal versed sine* of the true distance;

which will be found in Table 28, either in the column corresponding to the apparent distance, or in one of those immediately adjoining to it.

Note. *In taking the decimal suversed sine from Table* 28, *the arc is conceived to be increased by one minute.*

Remarks. 1. If the objects are vertically over each other—that is, if the difference of their apparent altitudes is equal to the apparent distance, take the sum of the corrections of altitude, and add it to the apparent distance, if the moon's altitude is the greater, but subtract if the moon's altitude is the less, and the sum or remainder will be the true distance.

2. If the distance between the objects pass through the zenith, or the objects be on opposite verticals, that is, when the supplement of the sum of the apparent altitudes is equal to the apparent distance, take the difference between the corrections of altitude, and add to it the apparent distance when the moon's correction is the less, but subtract it when the moon's correction is the greater, and the sum or remainder will be the true distance.

Example I.

If the apparent distance of the centres of the sun and moon be 111° 27′ 1″, the apparent altitude of the sun's centre 24° 40′, of the moon's 16° 53′, and her horizontal parallax 54′ 56″, required the true distance?

Min. ☽'s parallax 54′.

	Table 24.		Table 25.		
☽'s apparent altitude	16° 50′	48′ 33″	60° 8′	8″	
	0 3	0 1	0 0	2	
Seconds of parallax	0 50	0 48	0 0	9	
	0 6	6	0 0	1	
Correction of ☾'s altitude		49 28			
☉'s altitude	24 40 Correction	1 56	0 0	2	
Diff. corrections		47 32	60 8	22	aux. arc.

To clear the distance by the first method.

☽'s apparent altitude	16°	53′	0″
☉'s apparent altitude	24	40	0
Sum of apparent altitudes	41	33	0
Diff. corrections	0	47	32
Sum of true altitudes	42	20	32

					Parts for ″
Sum of apparent altitudes . . .	41°33′ 0″				
Auxiliary arc	60 8 22				
Apparent distance	111 27 1				
Sum of aux. arc and preceding one	101 41 22	vers	02502	. . .	104
Difference of ditto	18 35 22	vers	52139	. . .	33
Sum of aux. arc and following one	171 35 23	vers	89230	. . .	16
Difference of ditto	51 18 39	vers	74757	. . .	150
Sum of true altitudes	42 20 32	suvers . . .	39043	. . .	91
		Sum of parts for ″	394	. . .	:

	° ″ ′	Vers true dist	58065
	110 58 0	vers	57825
	53	. . . . .	240 { parts for ″ of true distance.
True distance . . .	110 58 53		

To clear the distance by the second method.

As above ☽'s correction	49′ 28″	☽'s apparent altitude . .	16°53′ 0″
⊙'s correction	1 56	⊙'s apparent altitude . .	24 40 0
Sum corrections. . . .	51 24	Difference of apparent alts.	7 47 0
		Sum corrections	− 51 24
		Difference of true altitudes	6 55 36

					Parts for ″
Diff. of apparent altitudes . .	7°47′ 0″				
Auxiliary arc	60 8 22				
Apparent distance	111 27 1				
Sum of aux. arc and preceding one	67 55 22	suvers . . .	75685	. . .	170
Difference of ditto	52 21 22	suvers . . .	10606	. . .	147
Sum of aux. arc and following one	171 35 23	vers	89230	. . .	16
Difference of ditto	51 18 39	vers	74757	. . .	150
Difference of true altitudes . .	6 55 36	vers	07278	. . .	21
		Sum of parts for ″ . .	504	. . .	:

		Vers true distance . .	58060
	110°58′ 0″	vers	57825
	52	. . . . .	235 { parts for ″ of true distance.
True distance . .	110 58 52		

Example II.

Given ☽'s apparent altitude 36° 28′, that of a planet 24° 43′, their apparent distance 71° 46′ 24″, ☽'s horizontal parallax 58′ 31″, and the planet's 29″, required the true distance?

Min. ☽'s parallax 58′.

	Table 24.		Table 25.	
☽'s apparent altitude	36°20′	45′ 21″	60°18′	53″
	0 8	0 1	0 0	4
Seconds parallax	0 30	0 24	0 0	10
	0 1	0 1	0 0	0
		45 47		
Planet's apparent alt. 24°43′(ref.)2′ 4″	Cor. 1 38, Table 27		0 0	7
Parallax, Table 26 0 26				
Sum of corrections		47 25	60 19	14 aux. arc.

To compute the true distance by the second method.

☽'s apparent altitude	36°28′ 0″		
Planet's ditto	24 43 0		
Difference of apparent altitudes	11 45 0		
Sum of corrections	+ 47 25		
Difference of true altitudes	12 32 25		
Difference of apparent altitudes	11°45′ 00″		
Auxiliary arc	60 19 14		
Apparent distance	71 46 24		
			Parts for ″
Sum of aux. arc and preceding one	72° 4′ 14″	suvers 07633	213
Difference of ditto	48 34 14	suvers 61530	168
Sum of aux. arc and following one	132 5 38	vers 70211	136
Difference of ditto	11 27 10	vers 19902	9
Difference of true altitudes	12 32 25	vers 23830	26
Sum of parts for ″		552	:
Vers true distance		83658	
	71°33′ 0″	vers 83523	
	29	135	parts for ″ of true distance.
True distance	71 33 29		

Example III.

If the moon's apparent altitude be 6° 25′, and that of a fixed star 37° 40′, their apparent distance 50° 27′ 36″, and ☽'s horizontal parallax 55′ 14″, required the true distance?

Min. ☽'s parallax 55′.

	Table 24.		Table 25.	
☽'s apparent altitude	6°24′	46′ 41″	60° 2′	39″
	0 1	0 1	0 0	1
Seconds parallax	0 10″	0 10	0 0	1
	0 4	0 4	0 0	0
Correction ☽'s altitude		46 56		
☼'s apparent altitude	37° 40′ cor.	1 14	0 0	0
Difference of corrections		45 42	60 2	41 aux. arc.

☽'s apparent altitude	6° 25′ 0″
☼'s apparent altitude	37 40 0
Sum of apparent altitudes	44 5 0
Difference of corrections	0 45 42
Sum of true altitudes	44 50 42

To compute the true distance by the first method.

Sum of apparent altitudes	44° 5′ 0″				
Auxiliary arc	60 2 41				
Apparent distance	50 27 36				Parts for ″
Sum of aux. arc and preceding one	104 7 41	vers	43897		193
Difference of ditto	15 57 41	vers	38498		53
Sum of aux. arc and following one	110 30 17	vers	50207		77
Difference of ditto	9 35 5	vers	13955		4
Sum of true altitudes	44 50 42	suvers	08956		62
Sum of parts for ″			389		
Vers true distance			55902		
	49° 54′ 0″	vers	55876		
	7		26	parts for ″ of true distance.	
True distance	49 54 7				

In clearing the distance, to allow for the spheroidal figure of the earth.

Observe the azimuths of the objects, reckoning from the south in north latitude, and from the north in south latitude; and with the reduction of lat from Tab. 13, taken as a distance, in Tab. 2, and the azimuth of each object as a course, when less, but its supplement when more than 90°, the correction of the object's alt is found in the latitude column, to be added to the apparent alt when the azimuth is less, but subtracted from it when the azimuth is more than 90°.

The corrections of alt may be taken to the nearest minute, and no great precision is required in the azimuths.

With the apparent alts thus corrected, the apparent distance, and the moon's horizontal parallax adapted to the latitude by Tab. 12, clear the distance by either of the preceding methods, and the result will be the true distance, adapted to the spheroidal figure of the earth.

Example.

If the azimuth of the sum in the example (page 265) be S 24° W, that of the moon S 126° W, and the lat 40° N, required the true distance?

The reduction of par^{x} by Tab. 12 is about 5″, whence the reduced par^{x} is 54′ 51″; the reduction of lat by Table 13 is 11′ 16″=11′·3

nearly: with which as a dist, and 24°, the sun's azimuth, as a course, and 54°, the supplement of the moon's azimuth, as a course, we have the correction of the sun's altitude = 10′·3 = 10′ 18″ +, and the correction of the moon's altitude = 6′·64 = 6′ 38″ −. Hence the sun's apparent altitude corrected for the figure of the earth is 24° 50′ 18″, the moon's 16° 46′ 22″, the moon's reduced par^{x} 54′ 51″, and the app distance as before 111° 27′ 1″. With these data, by either of the foregoing methods of clearing the distance, the true distance is found 110° 58′ 48″, differing 4 or 5 seconds from that found as before without allowing for the earth's figure.

In sea practice, however, the corrections of altitude for the figure of the earth are generally neglected, as they are in all the following examples.

Examples for Exercise.

In each of the following examples the true distance is required?

No.	Apparent Altitude of ⊙, or a fixed ✳.	☽'s apparent Altitude.	Apparent central Distance.	☽'s Horiz. Parallax.	True Distance.
	° ′	° ′	° ′ ″	′ ″	° ′ ″
1	⊙ 86 3	39 18	46 45 0	53 51	46 4 25
2	✳ 29 47	57 22	27 35 0	60 3	28 8 24
3	⊙ 60 5	63 12	51 3 21	58 30	50 41 15
4	✳ 34 28	10 42	49 18 38	61 11	48 45 32
5	⊙ 8 26	19 24	120 18 46	57 14	120 1 46
6	✳ 43 27	40 9	18 21 35	60 20	18 8 12
7	✳ 53 13	57 32	60 13 49	60 52	59 48 12
8	⊙ 72 26	18 30	81 2 28	60 58	80 9 33
9	⊙ 60 33	9 26	70 36 16	59 57	69 49 12

☽ and Planets.

No.	☽'s apparent Altitude.	Planet's appar. Alt.	☽'s Dist. from Planet.	☽'s Horizontal Parallax.	Planet's Parallax.	True Distance.
	° ′	° ′	° ′ ″	′ ″	″	° ′ ″
10	58 36	16 23	69 37 20	56 0	31	69 40 30
11	80 4	35 30	60 4 3	61 16	18	59 58 57
12	16 26	29 41	98 15 31	60 35	20	97 45 4
13	50 14	51 3	40 0 0	54 50	25	39 44 42
14	62 12	38 27	37 50 34	55 13	23	37 58 14

From the moon's known or computed right ascension, or distance from the sun or a star, to find the Greenwich time, when the right ascensions or distances are given for every hour.

Take the two right ascensions or distances which the given one falls between, (and they will always be found on the given day, or the preceding or following one,) and place them below the given one in the order of time in which they stand in the Ephemeris, and take the difference between the middle one and each of the others.

Then to ·4771 (the proportional log of 60m) add the proportional logarithm of the less difference, and the complement to 10 of the proportional logarithm of the greater difference, and the sum, rejecting 10 from the index, will be the proportional logarithm of a portion of time, which, added to the time corresponding to the first right ascension or distance, will give the Greenwich time.

Example.

If the moon's distance from a star be 47° 12′ 50″ at 9h, and 46° 40′ 35″ at 10h, and the true distance be found by computing from an observation to be 46° 58′ 19″, what is the Greenwich time?

True dist	46° 58′ 19″		
Dist at 9h.....	47 12 50		
Following dist ..	46 40 35		·4771
Diff of 1st and 2d	14 31	..... Prop log	1·0934
2d 3d	32 15	Comp to 10 of Prop log	9·2533
	0h 27m 0s	Prop log	·8238
Time of 1st dist..	9		
Greenwich time ..	9 27 0		

Examples for Exercise.

The right ascension of the moon on September 13, 1835, being as given at p. 228, required the Greenwich time corresponding to each of the following right ascensions?

	☽'s Right Ascension.	Answer. Greenwich Time.
	h m s	h m s
1.	4 2 20·23	1 23 26·7
2.	4 6 12·86	3 18 10·7
3.	4 11 59·37	6 8 8·2
4.	4 0 46·53	0 37 8·0

Given the moon's right ascension, or her true distance from the sun or a star, to find the apparent time at Greenwich, when the right ascensions or distances are given for every third hour.

For the given day, or in that preceding or following it, take from the Nautical Almanac the two right ascensions or distances between which the given one falls, and write them under the given one in the order of time in which they stand in the Almanac. Take the difference between the middle one of these three and each of the others, and subtract the

proportional log of the greater difference from the proportional log of the less, and the remainder will be the proportional log of the time to be added to that corresponding to the first right ascension or distance taken from the Almanac, for the required Greenwich apparent time.

Note. If the given distance be exactly found in the Almanac, the apparent time at Greenwich will be found above it.

If the right ascensions and distances are given for mean time, the Greenwich mean time will be found as above.

Example.

On September 16, 1823, the true distance of the moon's centre from Antares was 65° 49′ 30″, required the apparent time at Greenwich?

True distance . . .	65° 49′ 30″				
Dist. per Naut. Alm. see Table 31 .	at 6h 64 34 42, first diff.	1° 14′ 48″, prop. log	.	3814
Distance at . . .	9h 66 5 2, second diff.	1 30 20, prop. log	.	2994
		2h 29m 2s prop log	.	820
Time of first distance . . .		6 0 0		
Greenwich time		8 29 2		

The Greenwich time being computed as above, to find the correction of it in account of second differences.

Find the second difference of distance, as in Prob. 16, page 225, and with the change of distance in three hours, at the top, and the Greenwich time past 0, 3, 6, &c. hours, computed as above in the side column, take the number from the following table, and multiply it by the second difference for the required correction.

Then if the equation of second difference is *additive*, subtract the correction in increasing, and add it in decreasing distance; and the contrary when the equation of second difference is *subtractive*.

Hour, &c., by even proportion.		Change of distance in three hours.			Hour, &c., by even proportion.	
		1° 10′	1° 30′	1° 50′		
h	m	s	s	s	h	m
0	0	·00	·00	·00	3	0
0	20	·13	·10	·08	2	40
0	40	·22	·17	·15	2	20
1	0	·28	·22	·18	2	0
1	20	·32	·25	·20	1	40
1	30	·32	·25	·20	1	30

Thus in the preceding example we have the following distances:

3h	63°	4′	31″
6	64	34	42
9	66	5	2
12	67	35	31
	130	40	2
	130	39	44
			2)18
Second diff			9, equa of second diff *subtractive*.

With 1° 30′ at the top, and 2h 29m at the side, we have ·13s in the table. Hence ·13s × 9 = 1s·17 the correction of Greenwich time, *additive*, as the equation of second difference is subtractive, and the distances are increasing. Hence the true Greenwich app time is 8h 29m 2s + 1s = 8h 29m 3s.

This minute correction is not applied in the following examples; but it has been thought right to show how it may be found when for the sake of insuring extreme accuracy it may be required.

Examples for Exercise.

In each of the following examples the time at Greenwich is required?

No.	Date at Place of Observation.	☽'s true Distance from ☉ or ✳.				Time at Greenwich.			
			°	′	″		h	m	s
1	September 12, 1823	☉	98	40	46	September 12,	13	47	22
2	September 9, 1823	☉	70	14	21	September 10,	0	23	50
3	September 14, 1823	α Pegasi	64	18	40	September 14,	7	32	4
4	September 23, 1823	Pollux	61	22	5	September 23,	19	59	10
5	September 25, 1823	☉	113	10	8	September 25,	6	0	0
6	September 22, 1823	Fomalhaut	56	11	29	September 21,	19	56	38

The distances of the moon from the sun and principal fixed stars are given in Table 31, for September 1823, in the form in which they were then published in the Nautical Almanac. Since 1834 the distances have been given as in the following specimen, which is taken from the Almanac for 1836.

Day of the Month.	August 1836. *Mean Time*, Lunar Distances.								IX^h
	Star's Name and Position.		Noon.	P. L. Diff.	III^h	P. L. Diff.	VI^h	P. L. Diff.	
1	α Aquilæ	W	° ′ ″ 71 29 13	3475	° ′ ″ 72 50 5	3478	° ′ ″ 74 10 54	3481	&c. for every third hour of the day.
	Fomalhaut	W	38 3 20	3033	39 32 52	3018	41 2 43	3007	
	Aldeberan	E	61 13 26	2596	59 34 25	2616	57 55 52	2636	
	Mars	E	71 43 26	2779	70 8 31	2798	68 34 1	2818	
	Sun	E	123 0 8	2897	121 27 45	2916	119 55 46	2935	
2	α Aquilæ	W	82 13 38	3528	83 33 31	3540	84 53 11	3553	
	Fomalhaut	W	50 4 28	2995	51 34 47	2998	53 5 2	3003	
	α Pegasi	W	35 3 4	4065	36 13 40	3978	37 25 41	3905	
	Aldeberan	E	48 14 1	2753	46 38 38	2778	45 3 41	2799	
	Mars	E	59 15 39	2931	57 43 59	2948	56 12 41	2967	
	Sun	E	110 52 10	3046	109 22 54	3064	107 54 1	3082	

W signifies that the sun or star is *west*, and E that it is *east* of the moon, and P. L. diff is the prop log of the distances between which it stands. All the objects in distance are found at once by referring to the day of the month. Thus we see above that on the 2d of August, 1836, α Aquilæ, Fomalhaut, and α Pegasi are in distance *west*, and Aldeberan, Mars, and the sun *east* of the moon.

To find the Greenwich time from a given distance, when the computed distances are arranged in this manner, seek in the Nautical Almanac the two computed distances of the object observed between which the given distance falls, take out the preceding of these distances and the prop log which follows it. Subtract this prop log from that of the difference between the given distance and the said preceding one, and the remainder is the prop log of a portion of time, which, added to the time corresponding to the preceding distance in the Almanac, will give the Greenwich time.

Example.

If on August 2, 1836, the distance of the moon from Mars is 56° 30′8″, required the Greenwich time?

Given dist	56° 30′ 8″		
Dist at 3h	57 43 59	P. L. diff....	2948
	1 13 51	P. L.....	3869
	2h 26m 56·5s	P. L.	881
Time of preceding dist	3		
Greenwich time	5 26 56·5		

Examples for Exercise.

Required the Greenwich time corresponding to each of the following distances?

		Dist.	Answer.
August 1st, 1836	☽ from Fomalhaut	40° 13′ 49″	4h 22m 3s
	☽ from Mars	70 57 29	1 27 8
2d	☽ from α Pegasi .	37 44 12	6 45 30
	☽ from Sun	109 43 20	2 18 47

TO FIND THE LONGITUDE BY LUNAR OBSERVATIONS.

With the time by the watch when the observations are taken, and the longitude by account, find the Greenwich time by account, as in Problem 4, page 215, and for that time take the moon's semidiameter and horizontal parallax from the Nautical Almanac, correcting the semidiameter by Table 14, and the parallax by Table 12. Take the sun's semidiameter for the given day, and correcting the observed altitudes for semidiameter and dip, call the results the *apparent altitudes.*

Add the sum of the sun and moon's semidiameters to the observed distance, if the sun is one of the objects observed; but if the observed distance is of the moon's limb from a star, add her semidiameter to the observed distance, or subtract it, according as the distance is measured from the nearest or farthest limb, and the result will be the *apparent central distance.*

The semidiameters ought, in strictness, to be corrected by Table 15; and, in practice, the inclination of the semidiameter to the horizon, to enter the table, may in general be estimated near enough by the eye; but this correction, being in all cases small, and in most cases utterly insignificant, is in sea practice generally disregarded.

From the apparent altitudes, the parallaxes, and apparent distance, compute the true distance, (see page 263,) and find the mean time at Greenwich, to which the true distance corresponds, by the last two problems.

Then if the sun or the star be at a proper distance from the meridian, compute from its true altitude, &c., the apparent time, and thence by applying the equation of time, the *mean time* at the place of observation, (see page 248), and the difference between this mean time, and the mean time at Greenwich, found from the distance, will be the longitude of the place in time; *west* if the Greenwich time is *before*, but *east* if the Greenwich time is *behind* the time at the place of observation.

The difference between the time found from the distance, and the time by a chronometer when the distance is taken, will be the error of the chronometer for mean Greenwich time, if the distance is correctly observed, and thus the error and rate of a chronometer may be found at sea.

If the sun or the star be too near the meridian for computing from its altitude the time with exactness, or if the altitudes have been indifferently observed, the error of the watch by which the times of taking

the distances are noted must be found by altitudes taken for the purpose, when the sun or a known fixed star bears nearly east or west, or is, at any rate, at any considerable azimuthal distance from the meridian. If the watch be found slow for mean time, add its error to the time which it showed when the distances were observed; but if fast, subtract its error, and the sum or remainder will be the mean time at the meridian where the error of the watch was found, at the instant when the distances are measured; the difference between which time and the Greenwich time, found as above from the distance, will be the longitude of the place where the altitudes are taken for finding the error of the watch.

But it may sometimes happen that the lunar distance can be measured, when, from the obscurity of the horizon, the altitudes cannot be observed at all. In this case, the altitudes for clearing the distance *must be computed;* but, to compute the altitudes, it is necessary that the time at the place of observation should be known. Let therefore the error of the watch be found by altitudes, taken at some convenient opportunity, before or after the distances are observed. Compute from the log the difference of longitude made in the interval between taking the distances and taking the altitudes for the error of the watch; and if the distances are taken to the *eastward* of the altitudes, *add* the difference of longitude in time to the time of taking the distances, corrected by the error of the watch; but *subtract* it if the distances are taken to the *westward* of the altitudes; and the sum or remainder will be the time at the place where the distances were taken at the instant at which they were observed. Then with this time, the latitude at the same instant deduced from the log, the declinations, &c. of the objects, let their apparent altitudes be computed, as shown at p. 260, and with the altitudes and distance compute the true distance, and thence find the Greenwich time and longitude as before.

Since 1834, the lunar distances in the Nautical Almanac show the mean time at Greenwich; and the apparent time at the place of observation, deduced from altitudes, must then be converted into mean time, by applying the equation of time with the sign given in the Almanac.

In finding the longitude by chronometer, it is not now necessary to reduce the mean Greenwich time into apparent time, to take the data from the Almanac; the *mean time* at the place of observation compared with the *mean time at Greenwich*, shown by the chronometer, will give the longitude of the place in time.

The mean refractions may be corrected for the state of the barometer and thermometer (see Table 11); but very low altitudes should, if possible, be avoided, when minute accuracy in the result is desired.

Example I.

On September 12, 1823, in latitude 26° 30′ N, longitude by account 24° W, at 5h 34m P. M., per watch, the altitude of ☉ was 7° 37′ —, of ☽ 35° 35′, distance of their nearest limbs 95° 18′ 17″, height of the eye 25 feet, required the longitude?

Time per watch	5h 34m
Longitude 24° W, in time . . .	1 36
Greenwich time by account . . .	7 10

☽'s semidiameter at noon	14′ 52″	— 3″	☽'s hor. parallax at noon	54′ 31″	—9″
Correction for Green time	— 2		. . . . .	— 5	
	14 50		Equatorial parallax . .	54 26	
Aug for alt, Table 14 . .	+ 9		Red for lat, Table 12	— 2	
☽'s true semidiameter . .	14 59		☽'s reduced hor par .	54 24	
Altitude ☉	7° 37′ 0		Altitude ☽	35° 35′ 0″	
Semidiameter	+ 15 56		Semidiameter . . .	+ 14 59	
	7 52 56			35 49 59	
Dip	— 4 55		Dip	— 4 55	
☉'s apparent altitude . .	7 48 1		☽'s apparent altitude .	35 45 4	
Correction	6 30				
☉'s true altitude . . .	7 41 31				

Min. ☽'s parallax 54′.

	Table 24.			Table 25.		
☽'s apparent altitude	35° 40′	42′ 28″	. . . .	60° 17′ 12″		
	0 5	0 3	. . . .	0 0 2		
Sec. ☽'s parallax	0 20″	0 16	. . . .	0 0 7		
	0 4	0 3	. . . .	0 0 1		
Correction ☽'s altitude		42 50				
☉'s apparent alt 7° 48′ correction .		6 30	. . . .	0 0 2		
Difference of corrections		36 20	. . . .	60 17 24		aux. arc.

☽'s apparent altitude . .	35° 45′	4″	Observed distance . . .	95° 18′	17″
☉'s apparent altitude . .	7 48	1	☽'s semidiameter . . .	0 14	59
Sum of apparent altitudes .	43 33	5	☉'s semidiameter . . .	0 15	56
Difference of corrections .	0 36	20	Apparent central dist . .	95 49	12
Sum of true altitudes . .	44 9	25			

The true distance computed by the first method.

Sum of apparent altitudes	43°	33′	5″			
Auxiliary arc	60	17	24			
Apparent distance	95	49	12			Parts for ″
Sum of auxiliary arc and preceding one	103	50	29	vers	39098	137
Difference of ditto	16	44	19	vers	42345	26
Sum of auxiliary arc and following one	156	6	36	vers	14254	70
Difference of ditto	35	31	48	vers	86053	136
Sum of true altitudes	44	9	25	suvers	17316	119
				Sum of parts for ″	488	:
				Vers true distance	99554	
	95°	42′	0″	vers	99320	
			49		234	parts for″ of true distance.
True distance	95	42	49			

To find the mean time at Greenwich.

True distance	95°	42′	49″				
Distance at 6h	95	8	17	first diff.	0° 34′ 32″	prop log	7170
Distance at 9h	96	30	13	second diff.	1 21 56	prop log	3418
					1h 15m 52	prop log	3752
Time of first distance					6 0 0		
Mean time at Greenwich					7 15 52		

To find the mean time at the place of observation.

⊙'s dec at noon	4°	24′	7″ N	— 22′ 56″	Green time 7h 16m, log, Table 30,		5189
Cor. for G T	—	6	57		Daily change ⊙'s dec 22′ 56″ do.		198
⊙'s true dec	4	17	10		Cor. ⊙'s dec for Green T 6′ 57″ do.		5387
	90						
⊙'s polar dist	85	42	50				

In the same way the equation of time is found to be 3m, 42s, *sub.* from app time

⊙'s true altitude			7°	41′	31″	
Latitude			26	30	0	sec ·048209
⊙'s polar distance			85	42	50	cosec ·001216
Sum		2)	119	54	21	
Half sum			59	57	10	cos 9·699582
Remainder			52	15	39	sin 9·898073
Tab. 5* App time at place of observation			5h	34m	8s	9·647080
Equat time, *sub*				3	42	
Mean time at place			5	30	26	
Ditto at Greenwich			7	15	52	
Diff			1	45	26	long in time W = 26° 21½′ W.

Example II.

On September 27, 1823, at 5h 7m A. M. per watch, in latitude 28° 37′ S, longitude by account 112° W, the altitude of ♃ was 34° 20′, and of Regulus 10° 40′ +, distance of the star from ☽'s

nearest limb 53° 35′ 39″, height of the eye 12 feet; required the longitude?

Time per watch	17h 7m September 26.
Longitude 112° W, in time .	7 28
Greenwich time by account . .	0 35 September 27.

☽'s semidiameter at noon	16′ 6″ + 2″	☽'s hor parallax at noon	59′ 7″ + 6″
Correction for Green time	0 0	. . . . .	0
	16 6	Equatorial parallax . .	59 7
Aug for altitude . . .	9	Reduction for latitude .	3
☽'s true semidiameter .	16 15	☽'s red hor par	59 4

Altitude ♃	34° 20′ 0″	☼'s observed altitude	10° 40′ 0″
Semidiameter.	+ 16 15	Dip	— 3 25
	34 36 15	☼'s apparent altitude	10 36 35
Dip	— 3 25	Refraction . . .	0 4 58
☽'s apparent altitude . .	34 32 50	☼'s true altitude .	10 31 37

Min. ☽'s parallax 59′.

	Table 24.	Table 25.
☽'s apparent altitude	34° 30′ . . . 47′ 10″	. . . . . 60° 18′ 22″
	0 3 . . . 0 4	. . . . . 0 0 1
Sec parallax . . .	0 4″ . . . 0 3	. . . . . 0 0 1
Correction ☽'s altitude	47 17	
☼'s apparent altitude	10° 37′, cor. 4 58	. . . . . 0 0 1
Sum of corrections	52 15	. . . . . 60 18 25 aux. arc.

☽'s apparent altitude	34° 32′ 50″		
☼'s apparent altitude	10 36 35	Observed distance	53° 35′ 39″
Diff apparent altitudes	23 56 15	☽'s semidiameter	+ 16 15
Sum of corrections	0 52 15	Apparent central dist	53 51 54
Difference of true altitudes . .	24 48 30		

The true distance computed by the second method.

Difference of apparent altitudes . . .	23° 56′ 15″			
Auxiliary arc	60 18 25			
Apparent distance	53 51 54			Parts for ″
Sum of auxiliary arc and preceding one	84 14 40	suvers	00188	. . . 97
Difference of ditto	36 22 10	suvers	05066	. . . 145
Sum of auxiliary arc and following one	114 10 19	vers	09392	. . . 84
Difference of ditto	6 26 31	vers	06297	. . . 17
Difference of true altitudes	24 48 30	vers	92222	. . . 60
	Sum of parts for ″ . .		403	. . . :
	Vers true distance . .		13568	
	54° 5′ 0″	vers	13392	
	45		176	parts for ″ of true distance.
True distance	54 5 45			

To find the mean time at Greenwich.

True distance	54° 5′ 45″			
Distance at noon, Sept. 27,	54 20 29	first difference	0° 14′ 44″	P. log 10870
Distance at . . .	3h 52 34 58	second difference	1 45 31	P. log 2319
		September 27 .	0 25 8	P. log 8551
			24 0 0	

Greenwich mean time, September 26, 24 25 8 for the astronomical time at the place of observation being on the 26th, the time at Greenwich must be estimated from the noon of the same day.

To find the mean time at the place of observation.

☉'s R A, September 27, at noon, Greenwich time,		12h 13m 2s	+ 3m 37s
Correction for 0h 25m past noon		0 0 5	
☉'s reduced R A		12 13 7	
✳'s R A, Jan. 1, 1820,	9h 58m 47s	+ 3 21s	Declination . 12° 50′ 36″ N	−17·23′
3 21s × 3¾ years = . .	+ 12		17·23 × 3¾ years =	− 1 4
✳'s reduced R A . .	9 58 59		✳'s red dec	12 49 32 N
				90 0 0
			✳'s pol dist	102 49 32

✳'s true altitude . .	10° 31′ 37″		
Latitude	28 37 0	sec	·056583
✳'s polar distance . .	102 49 32	cosec	·010973
Sum . . . . . 2)	141 58 9		
Half sum	70 59 4	cos	9·512985
Remainder	60 27 27	sin	9·939507
Table 5* ✳'s meridian distance .	19h 18m 56s		9·520048
✳'s R A	9 58 59		
R A meridian . . .	5 17 55		
☉'s R A	12 13 7		
App time at pl of obser	17 4 48		
Eq time *sub*	8 50		
Mean time at place . .	16 55 58		
Ditto at Greenwich . .	24 25 8		
Difference	7 29 10	long in time W, = 112° 17½′ W	

Example III.

On September 16, 1823, at noon, we were in latitude 28° 27′ N, and longitude by account 40° W; at 4h 1m 2s P.M. per watch, the altitude of ☉ was 30° 14′ −, and at 7h 40m 2s the distance of ☽'s nearest limb from Antares was 66° 27′ 38″, the ship having run from noon S W ½ W 5 miles an hour, height of the eye 12 feet; required the longitude when the distance was measured?

The distance run from noon till 4h P.M. is 20 miles, and till 7h 40m 38 miles, and with the course, 4½ points, and these distances, the diff lat made from noon till 4h P.M. is about 13, and the dep. 15·5 miles, and till 7h 40m the diff lat is about 24 miles; hence the lat, when the ⊙'s alt was observed for time, was nearly 28° 14′ N, and the long by account 40° 17′ W: and the lat, when the lunar was taken, was 28° 3′ N, and the long by account 40° 33′ nearly.

Again, from 4h P.M. till 7h 40m, the ship had run S W ½ W, about 18 miles, whence the departure which she had made in that time is 14 miles nearly, with which, and the middle latitude, nearly 28°, the difference of longitude which she has made is in time 1m 4s W.

To find the error of the watch from ⊙'s altitude.

Time per watch . .	4h	1m	2s	⊙'s declination at noon	2° 51′ 58″ N	−23′ 11″	
Long in time by acct.	2	41	8	Cor for Green time .	0	6	28
Green time by acct.	6	42	10	⊙'s decl at given time	2	45	30
					90		
				⊙'s polar distance .	87	14	30

Observed alt. ⊙	30°	14′	0″	⊙'s altitude . .	30°	25′	3″	
⊙'s semid . .	+	15	57	Latitude . . .	28	14	0	sec ·055010
	30	29	57	⊙'s polar distance	87	14	30	cosec ·000504
Dip	−	3	25		2) 145	53	33	
⊙'s app alt .	30	26	32		72	56	46	cos 9·467269
Cor of alt . .	—	1	29		42	31	43	sin 9·829919
⊙'s true alt .	30	25	3	Apparent time . .	3h	46m	41s	. . 9·352702
				Time per watch .	4	1	2	
				Watch fast for apparent time		14	21	

Time per watch when distance was observed	7h	40m	2s
Watch fast for time at the meridian on which the ship was at 4h P.M.	0	14	21
Apparent time at that meridian	7	25	41
Difference of longitude in time made since 4h P.M., West, sub. . .	0	1	4
Apparent time at the meridian on which the distance was taken . .	7	24	37
Longitude by account in time W	2	42	12
Greenwich time by account when the distance was observed . . .	10	6	49

The right ascension of the sun, and the right ascension, declination, &c. of the moon, and the star being reduced to this time, we have ⊙'s R. A. 11h 35m 1s, ☽'s R. A. 21h 2m 59s, ☽'s P. D. 105° 15′ 38″, ✳'s R. A. 16h 18m 36s, ✳'s P. D. 116° 1′ 50″, ☽'s horizontal semidiameter 14′ 52″, and parallax corrected by Table 14, 54′ 28″.

Apparent time	7h	24m	37s	R A mer	18h	59m	38s
☉'s R A	11	35	1	✳'s R A	16	18	36
R A mer	18	59	38	✳'s mer dist	2	41	2
☽'s R A	21	2	59	Half mer dist	1	20	31
☽'s mer dist	2	3	21	In degrees	20°	7′	45″
Half mer dist	1	1	40·5				
In degrees	15°	25′	7″				

To compute the moon's altitude.

Half ☽'s mer dist	15°	25′	7″	2 sin	18·849336		
☽'s polar dist	105	15	38	sin	9·984410		
Colat	61	57	0	sin	9 945733		
Diff	43	18	38				
Half diff	21	39	19	2 sec	20·063576	cos	9·968212
					2) 18·843055		
Arc 1	15	18	17	sin	9·421527	cos	9·984318
				Arc 2	63° 41′ 47″	sin	9·952530
					2		
			Less 90°		37 23 34		☽'s true alt
					42		Cor nearly
					36 41 34		App alt nearly
					42 24		True cor
					36 41 10		☽'s app alt

To compute the star's altitude.

Half ✳'s mer dist	20°	7′	45″	2. sin	19·073464		
✳'s polar dist	116	1	50	sin	9·953547		
Colat	61	57	0	sin	9·945733		
Diff	54	4	50				
Half diff	27	2	25	2. sec	20·100550	cos	9·949725
					2) 19·073294		
Arc 1	20	7	30	sin	9·536647	cos	9·972640
				Arc 2	56° 45′ 7″	sin	9·922365
					2		
			Less 90°		23 30 14		✳'s true alt
					2 11		Cor
					23 32 25		✳'s app alt
					13 8 45		Diff app alts ☽ and ✳
Aux. arc, Table 25, 60° 17′ 48″					13 53 20		Diff true alts

To compute the true distance and find the Greenwich time.

				☽'s hor semid . . .		14′ 52″	
				Aug		9	
						15 1	
				☽'s n. l. from ☼ . .		66° 37 38	
				App cent dist . . .		66 42 39	
Diff app alt	13°	8′	45″				
Auxiliary arc	60	17	48				
App dist	66	42	39				Parts for ″
Sum of 1st and 2d arcs . .	73	26	33	suvers	84825	. .	126
Diff	47	9	3	suvers	79868	. .	204
Sum 2d, 3d	127	0	27	vers	01815	. .	104
Diff	6	24	51	vers	06232	. .	13
Diff true alt	13	53	20	vers	29214	. .	29
	Sum of parts for ″			. .	476	. .	:

Vers true dist				02430		
	vers	66°	34′	02318		
			25″	112	parts for ″ of true dist	
True dist	66	34	25			
Dist at 9h . . .	66	5	2			
Following dist . .	67	35	31			
		29	23	Prop log	7872	
	1	30	29	Prop log	2987	
		58	27	Prop log	4885	
	9			App time at place	7h 24m 37s	
Mean time at Greenwich	9	58	27	Eq time *sub* . .	5	6
Ditto at place of obs .	7	19	31	Mean time . .	7	19 31
Long in time W . .	2	38	56	= 39° 44′ W		

Examples for Exercise.

In the following examples the time at the place of observation is deduced from ☉'s altitude observed with the distance, the longitude being required?

No.	Date, Civil Time.	Hour, &c. by Watch.	Lat.	Long. by Acct.	Altitudes.	Apparent Distance.	Height of the Eye.	True Distance.	Answer. Longitude.
1	1823. Sept. 8	h m s 3 28 10 P.M.	° ′ 38 10 N	° 35 W	☽ ° ′ 32 35 ☉ 32 46 −	n. l. ° ′ ″ 49 5 44	feet. 16	° ′ ″ 49 23 56	° ′ ″ 35 5 0 W
2	Sept. 10	4 5 40 P.M.	15 7 S	27 W	☽ 78 5 ☉ 25 45 −	n. l. 72 26 9	16	72 50 36	27 33 45 W
3	Sept. 29	7 30 14 A.M.	48 30 N	167 E	☽ 62 37 ☉ 13 26 +	n. l. 72 15 28	15	72 52 55	167 55 45 E
4	Sept. 12	4 15 7 P.M.	20 4 S	19 W	☽ 61 45 ☉ 22 39 −	n. l. 94 46 4	12	94 53 57	19 16 30 W
5	Sept. 25	7 25 16 A.M.	40 50 N	44 W	☽ 43 51 ☉ 15 24 +	n. l. 117 20 51	18	117 17 49	44 35 15 W
6	Sept. 14	3 50 18 P.M.	22 6 S	88 E	☽ 37 45 ☉ 27 59 −	n. l. 113 19 10	15	113 10 10	88 44 30 E
7	Sept. 30	9 14 48 A.M.	32 40 N	31° 9′ E	☽ 70 41 ☉ 37 16 +	n. l. 53 10 4	24	53 40 1	31 9 0 E
8	Sept. 29	9 3 5 A.M.	53 17 N	21° W	☽ 50 35 ☉ 23 36 +	n. l. 64 36 31	10	65 5 31	20 44 0 W

In the following examples the time at the place of observation is deduced from ✳'s altitude observed with the distance, the longitude being required?

No.	Date, Civil Time.	Hour, &c. by Watch.	Lat.	Long. by Acct.	Altitudes.	Apparent Distance.	Height of Eye.	True Distance.	Answer. Longitude.
9	1823. Sept. 8	h m s 8 45 0 P.M.	° ′ 24 50 S	° ′ 13 0 W	☽ ° ′ 10 38 Antares 42 19 −	f. l. ° ′ ″ 31 49 54	feet. 14	° ′ ″ 30 42 55	° ′ ″ 12 8 15 W
10	Sept. 16	7 48 0 P.M.	40 30 N	19 25 W	☽ 28 40 Antares 11 0 −	n. l. 65 47 50	16	66 5 33	19° 27½′ W
11	Sept. 24	7 36 0 P.M.	31 35 N	78 7 W	☽ 9 6 Marcab 42 16 +	n. l. 67 48 24	18	67 29 41	78 11¼ W
12	Sept. 15	7 55 0 P.M.	44 3 N	50 0 W	☽ 24 38 Marcab 36 42 +	f. l. 51 55 30	14	51 18 40	50 6 W
13	Sept. 27	5 7 0 A.M.	28 37 S	112 0 W	☽ 34 20 Regulus 10 40 +	n. l. 53 35 50	12	54 5 56	112 17½ W
14	Sept. 7	7 31 0 P.M.	4 21 S	44 0 W	☽ 12 32 Antares 51 6 −	f. l. 44 30 45	20	43 26 45	43 40 W

In the following examples the *true* apparent time at the place of observation is given, and the altitudes for clearing the distance are to be computed, the longitude being required?

No.	Date.	True appar. Time.	Lat.	Long by Acct.	Objects observed.	Observed Distance.	True Distance.	Longitude.
	1823.	h m s	° ′	°		° ′ ″	° ′ ″	° ′
1	Sept. 19	9 16 25 P.M.	38 20 N	23 E	} f. l. *a* Arietes	45 58 39	45 45 10	23 20¼ E
2	Sept. 27	5 40 9 A.M.	9 38 N	105 W	} f. l. *a* Arietes	58 34 57	58 17 50	104 38¼ W
3	Sept. 12	7 17 45 P.M.	8 18 S	21¼ W	} f. l. Fomalhaut	66 35 15	66 16 9	29 21 W
4	Sept. 12	6 17 24 P.M.	33 45 N	47 W	} n. l. Spica	64 15 35	64 30 39	47 13¼ W

To find the Rate of a Chronometer by Lunars.

At a time favourable for taking lunars let a set of distances with the altitudes be carefully taken, and the corresponding times noted by a chronometer. Take the mean of the times, altitudes, and distances respectively; clear the mean distance from the effects of parallax and refraction; and find the Greenwich mean time to which the corrected distance corresponds: the difference between which time and the mean of the times shown by the chronometer will be the error of the chronometer for Greenwich mean time, as deduced from that set of lunars. Continue for a day or two at convenient opportunities to take similar sets of lunars, and find from each set the error of the chronometer for Greenwich mean time, and the mean of all the several errors as determined may be taken as the error at the mean of the times when the different sets of lunars are observed.

It will contribute to greater accuracy in the result, if an equal number of sets of distances from objects *east* and *west* of the moon be obtained. But when this cannot be done, take the mean of the errors found from objects *east*, and also the mean from objects *west*, of the moon; and consider half the sum of these two means as the error for Greenwich time resulting from all the observations. A few days afterwards, let the error for mean Greenwich time be found from a series of independent sets of lunar distance in the same manner, and the difference of the two mean errors so found divided by the days, &c. between the mean of the times of each series, will be the *rate* of the chronometer. This rate, with the last found error, may be used in finding the longitude by the chronometer, till another error and rate can be obtained either by the same or some other method.

After having found as above the error of the chronometer on any day by a series of sets of lunar distances, embrace the first favourable opportunity to take altitudes for time at the place of observation, noting the times by the chronometer. To the mean of these times by the chronometer, apply the previously found error to obtain the Greenwich time; and from the latitude, the altitudes, and the other requisite data, (which may be obtained for the Greenwich time from the Nautical Almanac,

or the Tables in this book,) find the mean time at the place of observation; and the difference between that time and the Greenwich mean time, when the altitudes are taken, will be the longitude of the place in time.

Example.

If on August 1, 1836, the following results were obtained, required the error of the chronometer for Greenwich mean time?

Time by Chron.	By ☽'s Dist. from	Greenwich Mean Time.	Chron. fast, By W. Distances.	By E. Distances.
h m s		h m s	m s	
8 12 10	α Aquilæ W	8 37 56	25 46	
8 26 14	α Aquilæ W	8 52 27	26 13	
9 11 30	Fomalhaut W	9 37 5	25 35	
21 16 59	☉ E	21 42 31		25 32
21 30 37	☉ E	21 56 4		25 27
13 43 30	mean of times	Mean W	25 51	25 29 E
			25 29	
		Half sum	25 40	mean error.

Therefore, on August 1st, at 13h 43m 30s by the chronometer, its error is found by these observations to be 25m 39s fast for Greenwich mean time. A more accurate determination of the error might of course be expected from the mean of a greater number of observations, but the example just given is sufficient to explain the practical details of the method.

If in a similar way, on August 15th, at 4h 10m P. M. chronometer time, the mean error were found to be 23m 57s fast, then it would appear that in about 13d 14h 27m, the chronometer had lost 1m 42s, whence its rate would be 7·2s losing.

Again, if on August 15th, after the error and rate had been determined, the following altitudes of the sun's lower limb had been observed, lat. 38° 10′ N, height of the eye 15 feet, required the longitude?

	Time by Chron. h m s	Alt. ⊙ ° ′ ″		
	8 17 26	42 12 20	Declin noon, Aug. 15, 1836	° ′ ″ 13 59 22N — 18′ 54″
	17 53	42 7 30	Correction for 7h 54m	— 6 13
	18 29	42 2 15	Red declin	13 53 9
	18 59	41 57 50		90
Mean	8 18 12	42 4 59	Pol dist	76 6 51
Chro fast at 4h 10m	23 57	3 49 dip.	In the same way the equation of time is found to be 5m 5s, *add* to app	
	7 54 15	42 1 10		
Loss in 4h	1	57 cor		
Green time	7 54 16	42 0 13		
		15 50		
Alt		42 16 3		
Lat		38 10 0 sec	·104458	
P dist		76 6 51 cosec	·012881	
		156 32 54		
		78 16 27 cos	9·307985	
		36 0 24 sin	9·769306	
		h m s	9·194630	
App Time Table 5*		3 6 27		
Equat time		5 5		
Mean time at place		3 11 32		
Do Greenwich		7 54 16		
Long in time W		4 42 44 = 70° 41′ W		

To find the longitude by the eclipses of Jupiter's satellites.

By the immersions and emersions of these satellites are meant the instants of their vanishing in or re-appearing from the shadow of the planet.

To the mean Greenwich time given in the Almanac for the expected immersion or emersion, apply the longitude by account in time, adding it if east, and subtracting it if west, and the result is the mean time at the place of observation when the phenomenon may be looked for.

Begin to observe a few minutes before that time, and note the instant of mean time at which the immersion or emersion actually takes place, and the difference between that mean time, and the Greenwich time given in the Nautical Almanac, is the longitude of the place in time.

Thus, if I observe the immersion of Jupiter's first satellite at 11h 2m 12s mean time, and I find by the Nautical Almanac that it would take place at 9h 40m 15s Greenwich mean time, my longitude in time must be 1h 21m 57s east.

Examples for Exercise.

By the Nautical Almanac, the Greenwich mean time of the eclipses of Jupiter's satellites for a few days in December, 1836, are as under; those marked * being such as are visible at Greenwich.

1st Satellite.					2d Satellite.					3d Satellite.					4th Satellite.				
d	h	m	s		d	h	m	s		d	h	m	s		d	h	m	s	
1*	10	26	2·1	im	1	4	31	55·2	im	2*	12	35	26·4	im	5	6	12	36·0	im
3	4	54	21·5	im	4*	17	49	13·8	im	2*	16	7	41·2	em	5*	10	46	59·5	em
4	23	22	37·6	im	8	7	7	30·9	im	9*	16	33	18·8	im	22	0	11	4·2	im
6*	17	50	56·7	im	11	20	24	51·3	im	9	20	5	42·6	em	22	4	47	54·0	em
8*	12	19	13·6	im	15*	9	43	14·1	im	16	20	31	44·9	im					
10	6	47	32·1	im	18	23	0	39·7	im	17	0	4	18·1	em					

It is required then, from the data thus taken from the Nautical Almanac, to find the longitude of the places whence the eclipses were observed as under.

Ex.	1836.	Satellite.	Time by Chron.			Error of Chron. for time and place.			Ansr. Long.		
			h	m	s	h	m	s	°	′	″
1.	Dec.	3d, im, first,	7	2	5·5	0	20	3 slow,	36	56	45 E
2.	„	15th, im, second,	6	28	16·0	1	5	48 fast,	65	11	31 W
3.	„	2d, em, third,	5	40	28·6	0	37	26 slow,	147	26	27 W
4.	„	5th, em, fourth,	11	16	37·5	0	30	38 fast,	0	15	0 W
5.	„	18th, im, second,	17	41	20·8	0	25	4 fast,	86	5	43 W
6.	„	10th, im, first,	15	3	12	2	1	14 slow,	154	13	28 E

It has been generally supposed that these phenomena could not be observed at sea, from the difficulty of holding steadily a telescope of sufficient magnifying power to observe them; but Lieut. Lecount, R.N., assures us that, with a good sea telescope, he has often observed them, and deduced his longitude from the observations very satisfactorily.

To find the longitude from an observed occultation of a fixed star by the moon, when the true right ascension and polar distance of the star are known.

By applying the long by acct in time, to the time at the place of observation, when the occultation is observed, find the Greenwich time by account; and for that time take with the greatest exactness the sun's right ascension, and the moon's polar dist, semidiameter, and horizontal parallax; and her right ascension for the preceding and following hour. To the lat apply the red from Table 13, and to the parx the reduction from Table 12.

To the app time add the sun's right ascension, and the difference between the sum and the star's right ascension is its mer dist. Call this mer dist P, the star's polar dist p, its right ascension R, the reduced colat l, the moon's pol dist m, her reduced hor parx H, and her semid s.

Then add together sec $\frac{l+p}{2}$, cos $\frac{l \sim p}{2}$, and cot $\frac{P}{2}$, and the sum, rejecting 20, will be the tan of arc a, of the same affection as $\frac{l+p}{2}$.

Add together cosec $\frac{l+p}{2}$; sin $\frac{l \sim p}{2}$, and cot $\frac{P}{2}$, and the sum, rejecting 20, will be the tan of arc b, always acute. When l is greater than p, $a + b =$ arc c, and when l is less than p, $a - b =$ arc c.

Add together tan c, cosec l, cosec P, and prop log H, and the sum, rejecting tens, is prop log of arc d. When arc c is obtuse, $p + d =$ arc e, and when c is acute, $p - d =$ arc e.

Add together cosec l, cosec P, and prop log H, and with the sum S, and p, take the correction from the subjoined table, and applying it with its proper sign to e, call the sum or the remainder e'. The difference of m and e' is arc f.

To S add sin e', and the sum, rejecting tens, is the prop log of arc g.

To the prop logs of $s + f$ and $s - f$ add twice the sine of arc e, and half the sum, rejecting the tens, is the prop log of arc h.

Then the moon's right ascension $=$ R $\pm g \pm h$, where g is additive west of the meridian, and subtractive east; and h is additive at an emersion, and subtractive at an immersion.

Having found the moon's right ascension, the Greenwich time is found by the method given at page 269, and thence the longitude is known.

When the Greenwich time thus found differs considerably from that by account, take m for a minute or two earlier or later, and repeating the computations in which m enters, find the corresponding Greenwich time again; and then, by proportion, the true Greenwich time, or that to which the declination employed and the resulting right ascension both correspond, will readily be determined.

Table for Correction of *e*.

S	Star's Polar Distance, *p*.						
	60° +	65° +	70° +	75° +	80° +	85° +	90° +
	″	″	″	″	″	″	″
·50	16·5	13·2	10·3	7·5	5·0	2·5	0
·55	13·0	10·5	8·2	6·0	4·0	2·0	0
·60	10·3	8·3	6·5	4·7	3·2	1·5	0
·65	8·2	6·6	5·1	3·8	2·5	1·2	0
·70	6·5	5·2	4·1	3·0	2·0	1·0	0
·75	5·1	4·2	3·2	2·4	1·5	·8	0
·80	4·1	3·2	2·6	1·9	1·2	·6	0
·85	3·2	2·6	2·0	1·5	·9	·5	0
·90	2·6	2·1	1·6	1·1	·8	·4	0
·95	2·1	1·7	1·3	1·0	·6	·3	0
1·00	1·6	1·3	1·0	·7	·4	·2	0
1·10	1·0	·9	·6	·5	·3	·1	0
1·20	·6	·5	·4	·3	·2	·1	0
1·30	·4	·3	·3	·2	·1	·0	0
1·50	·2	·1	·1	·0	·0	·0	0
1·80	·0	·0	·0	·0	·0	·0	0
S	— 120°	— 115°	— 110°	— 105°	— 100°	— 95°	— 90°
	Star's Polar Distance, *p*.						

Example.

On Oct. 15th, 1829, at Bedford, lat about 52° 8′ N, long about 27′ W, Capt. W. Smyth, R.N., observed the emersion of Aldebaran from behind the moon, at 10h 1m 46s·61 app time, at which time the ✱'s right asc (R) was 66° 32′ 41″·8; polar dist (*p*) 73° 50′ 29″·4; and mer dist (P) 75° 30′ 43″·4; the moon's pol dist (*m*) 73° 18′ 44″·1; her reduced hor parx (H) 58′ 51″·4; her semid (*s*) 16′ 4″·3; her right ascension at 10h 66° 6′ 54″·1, and at 11h 66° 43′ 13″·2; and as the reduction of latitude is 11′ 8″, the reduced colat (*l*) is 38° 3′ 8″.

p 73°50′ 29″·4
l 38 3 8

$p + l$ 111 53 37·4, $\frac{p+l}{2} = 55°56′ 48″·7$

$p \sim l$ 35 47 21·4, $\frac{p \sim l}{2} = 17\ 53\ 40·7$

P 75 30 43·4, $\frac{\mathrm{P}}{2} = 37\ 45\ 21·7$

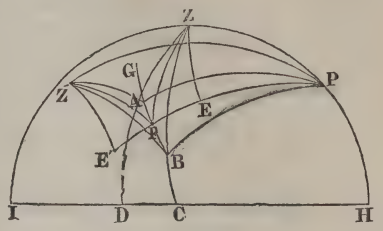
$\frac{p+l}{2}$	55°56′48″·7	sec	10·251841	cosec	10·081698		
$\frac{p \sim l}{2}$	17 53 40·7	cos	9·978465	sin	9·487516		
$\frac{P}{2}$	37 45 21·7	cot	10·111006	cot	10·111006		
a	65 30 2·9	tan	10·341312				
b	25 35 18·5	.....		tan	9·680220		
$a-b=c$	39 54 44·4	tan	9·9225				
l	38 3 8	cosec	·2102				
P	75 30 43·4	cosec	·0140	sum	·7097 S, cor fr tab 3″·1		
H	58 51·4	prop log	·4855				
d	41 59·0	prop log	·6322				
p	73 50 29·4						
$p-d=e$	73 8 30·4						
cor tab	3·1						
e	73 8 33·5	2 sin	19·9618	sin	9·9809		
m	73 18 44·1				·6906	prop log g, 36′42″ −	
$e \sim m=f$	10 10·6						
s	16 4·3						
$s+f$	26 14·9	prop log	·8361				
$s-f$	5 53·7	ditto	1·4848				
			2)2·2827				
			1·1413	prop log h 13′ 0″ +			
		✻ RA	66°32′41″·8				
			36 42, g −				
			65 55 59·8				
			13 0, h +				
							·4771
		☽'s RA.....	66 8 59·8	diff 2′ 5″·7	prop log 1·9341		
		Ditto at 10h ..	66 6 54·1	.. 36 19·1	comp do. 9·3048		
		11	66 43 13·2				
				0h 3m 27s·7	prop log 1·7160		
				10			
				10 3 27·7	Greenwich time.		
				10 1 46·6	Bedford ditto.		
		Long of Bedford, W		1 41·1	= 25′31″ W		

INVESTIGATION OF THE TRIGONOMETRICAL FORMULÆ WHICH FORM THE PRECEDING RULES FOR THE PRACTICAL SOLUTION OF THE MOST USEFUL PROBLEMS IN NAUTICAL ASTRONOMY.

Method of finding the latitude from two altitudes of the sun, and the time elapsed between the observations. (See p. 235.)

Let Z or Z′ be the zenith, I D C H the horizon, P the pole, A and B the places of the sun at the two times of observation, A D and B C the true altitudes, A Z, B Z, or A Z′, B Z′ the zenith distances, A P and

B P the polar distances, which, in the practice of this problem, may be considered as equal. Join A B, and bisect it by the perpendicular P F; and to P F, or P F produced, let the perpendicular Z E or Z′ E′ be drawn, and join Z F or Z′ F. Then A P B will be the elapsed interval of time between the observations, A P F half the elapsed time, Z P the co-latitude, Z P A the sun's meridian distance when the greater, and Z P B his meridian distance when the less altitude is observed, and Z P F his meridian distance at the middle time between the observations. And P F A being a right angle, Z F P or Z F E will be the complement of Z F A or Z F B.



In the right-angled triangle P F A we have by *Napier*, sin A P . sin A P F = rad . sin A F, whence $\frac{\text{sin A P . sin A P F}}{\text{rad}} = \text{sin A F}$, (arc 1;) and as A P F is always an acute angle, A F will also be *acute*.

In the same triangle we have rad . cos A P = cos A F . cos P F, whence $\frac{\text{rad . cos A P}}{\text{cos A F}} = \frac{\text{cos A P . sec A F}}{\text{rad}} = \text{cos P F}$, (arc 2;) and as A F is always acute, P F will be of the same affection as A P.

In the triangle Z F A we have (Prop. 18, p. 93) cos Z F A or sin Z F E $= \frac{\text{cos A Z} - \text{cos A F . cos F Z}}{\text{sin A F . sin F Z}}$; or cos A Z = cos A F . cos F Z + sin A F . sin F Z . sin Z F E; and in the triangle B F Z we have cos Z F B, or $-$ cos Z F A $= \frac{\text{cos Z B} - \text{cos F B . cos F Z}}{\text{sin F B . sin F Z}} = \frac{\text{cos Z B} - \text{cos A F . cos F Z}}{\text{sin A F . sin F Z}}$; or cos Z B = cos A F . cos F Z $-$ sin A F . sin F Z . cos Z F A = cos A F . cos F Z $-$ sin A F . sin F Z . sin Z F E.

We have then these two equations, viz.

cos A Z = cos A F . cos F Z + sin A F . sin F Z . sin Z F E and
cos B Z = cos A F . cos F Z $-$ sin A F . sin F Z . sin Z F E.

And, by taking their *sum* and *difference*, we have

cos A Z + cos B Z = 2 cos A F . cos F Z and
cos A Z $-$ cos B Z = 2 sin A F . sin F Z . sin Z F E.

But in the right-angled triangle Z F E, cos Z F = cos Z E . cos E F, and sin Z E = sin Z F . sin Z F E. Hence, by substitution, the two preceding equations become

cos A Z + cos B Z = 2 cos A F . cos Z E . cos E F and
cos A Z $-$ cos B Z = 2 sin A F . sin Z E.

Or $\sin A D + \sin B C = 2 \cos A F \cdot \cos Z E \cdot \cos E F$ and
$\sin A D - \sin B C = 2 \sin A F \cdot \sin Z E.$

From the latter of these equations we have

$$\sin Z E = \frac{\sin A D - \sin B C}{2 \sin A F}$$

and from the first, $\cos E F = \dfrac{\sin A D + \sin B C}{2 \cos A F \cdot \cos Z E}.$

But (Formula 3, p. 72)

$$\sin A D - \sin B C = 2 \sin \frac{A D - B C}{2} \cdot \cos \frac{A D + B C}{2}, \text{ and}$$

$$\sin A D + \sin B C = 2 \sin \frac{A D + B C}{2} \cdot \cos \frac{A D - B C}{2}.$$

These expressions substituted in the two preceding equations give

$$\sin Z E = \frac{2 \sin \frac{A D - B C}{2} \cdot \cos \frac{A D + B C}{2}}{2 \sin A F} = \sin \frac{A D - B C}{2} \cdot \cos \frac{A D + B C}{2} \cdot \operatorname{cosec} A F;$$ and

$$\cos E F = \frac{2 \sin \frac{A D + B C}{2} \cdot \cos \frac{A D - B C}{2}}{2 \cos A F \cdot \cos Z E} = \sin \frac{A D + B C}{2} \cdot \cos \frac{A D - B C}{2} \cdot \sec A F \cdot \sec Z E,$$ radius being unity; or, restoring the radius,

$$\frac{\sin \frac{A D - B C}{2} \cdot \cos \frac{A D + B C}{2} \cdot \operatorname{cosec} A F}{\text{rad}^2} = \sin Z E, \text{ (arc 3,) and}$$

$$\frac{\sin \frac{A D + B C}{2} \cdot \cos \frac{A D - B C}{2} \cdot \sec A F \cdot \sec Z E}{\text{rad}^3} = \cos E F, \text{ (arc 4.)}$$

Here F Z and Z E are always acute, therefore E F is also always acute.

Now when Z and P are on the same side of B A G, the great circle passing through the places of the sun at the time of observation, $P F - F E = P E$, otherwise $P F + F E$, or $P F + F E' = P E'$, or generally $P F \mp F E = P E$, (arc 5.)

In the right-angled triangle Z P E, rad . cos P Z, or rad . sin lat. $=$ $\cos E P \cdot \cos E Z$, hence $\dfrac{\cos E Z \cdot \cos E P}{\text{rad}} = \sin \text{lat.}$

Investigation of the method of finding the latitude from an altitude observed near the meridian, page 239.

Let l = lat, l' = colat, d = declin, p = pol dist, m = mer dist, z = mer zenith dist, and z' = the required reduction.

$$\text{Then } \cos m = \frac{\cos \overline{z + z'} - \cos l' \cdot \cos p}{m\, l' \cdot \sin p};$$

$$\text{whence } 2 \sin^2 \frac{m}{2} = \frac{\cos \overline{l' \sim p} - \cos \overline{z + z'}}{m\, l' \cdot \sin p}.$$

$$\text{But } \overline{l' \sim p} = z, \text{ therefore}$$

$$2 \sin^2 \frac{m}{2} = \frac{\cos z - \cos \overline{z + z'}}{\sin l' \cdot \sin p} = \frac{\sin z \cdot \sin z'}{\sin l' \cdot \sin p} \textit{ nearly.}$$

Hence $\sin z' = 2 \sin l' \cdot \sin p \cdot \operatorname{cosec} z \cdot \sin^2 \frac{m}{2}$, or z' in seconds of space $= \frac{2}{\sin 1''} \cos l \cdot \cos d \cdot \operatorname{cosec} z \cdot \sin^2 \frac{m}{2}$, *nearly*, and $\log \frac{2}{\sin 1''}$ is the constant log given in the rule.

Method of computing the amplitude and azimuth. (See pp. 242, 243.)

In the last figure let Z C represent the prime vertical, and D the place of a celestial object in the horizon, then the angle D Z C, measured by D C, will be the amplitude of the object at D.

Let P be the north pole, and A the place of an object above the horizon, then A Z P will be the azimuth from the north, A Z I the azimuth from the south, A P Z the hour angle, or the meridian distance of the object, A D its altitude, A Z its zenith distance, A P its polar distance, and Z P the co-latitude.

Put A D $= a$, A Z $= a'$, P Z $= l'$, and the latitude $= l$, and A P $= p$. Then to investigate the rule for the amplitude, we have, by Prop. 18, page 93, $\cos \text{A Z P} = \frac{\cos p - \cos a' \cdot \cos l'}{\sin a' \cdot \sin l'}$, which is equal to $\frac{\cos p}{\cos l}$ when a' equal 90°, or the object is in the horizon, as at D, radius being unity; or $\cos \text{D Z P } (= \sin \text{D Z C}) = \frac{\text{rad} \cdot \cos p}{\cos l} = \frac{\cos p \cdot \sec l}{\text{rad}} = \frac{\sin \text{dec} \cdot \sec \text{lat}}{\text{rad}}$, the rule given in p. 242 for computing the amplitude. And as l is always acute, D Z P will be of the same affection with p, or the amplitude D Z C will be of the same name with the declination.

For the azimuth we have (Prop. 19, Spherics) $\cos^2 \frac{\text{A Z P}}{2}$, or

$$\sin^2 \frac{AZI}{2} = \frac{\text{rad}^2 \cdot \frac{\sin a' + l' + p}{2} \cdot \frac{\sin a' + l' - p}{2}}{\sin a' \cdot \sin l'}, \text{ or} =$$

$$\frac{\text{rad}^2 \cdot \sin\left(\frac{90° - a + 90 - l + p}{2}\right) \cdot \sin\left(\frac{90° - a + 90° - l - p}{2}\right)}{\cos a \cdot \cos l} =$$

$$\frac{\sin\left(90° - \frac{a + l - p}{2}\right) \cdot \sin\left(90° - \frac{a + l + p}{2}\right) \cdot \sec a \cdot \sec l}{\text{rad}^2} =$$

$$\frac{\cos\left(\frac{a + l + p}{2} - p\right) \cdot \cos\left(\frac{a + l + p}{2}\right) \cdot \sec a \cdot \sec l}{\text{rad}^2}.$$

Whence $$\sin \frac{AZI}{2} =$$

$$\sqrt{\frac{\cos\left(\frac{a + l + p}{2} - p\right) \cdot \cos\left(\frac{a + l + p}{2}\right) \cdot \sec a \cdot \sec l}{\text{rad}^2}}.$$

Method of computing the hour angle, or the meridian distance of a celestial object. (See p. 248.)

Adopting the above notation, we have (Prop. 19, Spherics)

$$\sin^2 \frac{APZ}{2} = \frac{\text{rad}^2 \cdot \sin\left(\frac{a' + p - l'}{2}\right) \cdot \sin\left(\frac{a' + l' - p}{2}\right)}{\sin p \cdot \sin l'} =$$

$$\frac{\text{rad}^2 \cdot \sin\left(\frac{90 - a + p - 90 + l}{2}\right) \cdot \sin\left(\frac{90 - a + 90 - l - p}{2}\right)}{\sin p \cdot \cos l} =$$

$$\frac{\sin\left(\frac{p + l - a}{2}\right) \cdot \sin\left(90° - \frac{a + l + p}{2}\right) \cdot \sec l \cdot \text{cosec } p}{\text{rad}^2} =$$

or $$\frac{\sin APZ}{2} =$$

$$\sqrt{\frac{\sin\left(\frac{a + l + p}{2} - a\right) \cdot \cos\left(\frac{a + l + p}{2}\right) \cdot \sec l \cdot \text{cosec } p}{\text{rad}^2}}; \text{ and}$$

Table 5* contains the log of $\sin^2 \frac{APZ}{2}$, or $2 \log \sin \frac{APZ}{2}$.

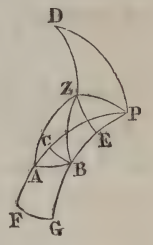
The direct solution of the preceding problems by spherics is very simple. To find the latitude by double altitudes, we have given first in the isosceles spherical triangle B P A, the two equal polar distances P B, P A, and the included angle B P A, the elapsed time, to find A B and the angle P A B. Then in the triangle Z A B are given the two

zenith distances B Z, A Z, and the side A B, to find the angle Z A B, the difference between which and P A B is Z A P, or the supplement of P A B + Z′ A B is Z′ A P; hence Z A P or Z′ A P is known. We have then Z A and A P, or Z′ A and A P, and the included angle in either case, to compute Z P or Z′ P, the co-latitude.

For the azimuth and hour angle, in the triangle A Z P, all the sides are given to compute A P Z, the hour angle, and A Z P, the azimuth, from H, the supplement of which is A Z I, the azimuth from I.

Method of computing the equation of equal altitudes. (See p. 252.)

Let P represent the pole, Z the zenith, A the place of the sun in the morning, D his place in the afternoon of the same day, when his zenith distance D Z is equal to A Z.



Then if the polar distances D P and A P are equal, the angles A P Z and D P Z will be equal, and consequently half of A P D, their sum, as measured by a chronometer, added to the time shown by the same chronometer when the sun is at A, will be the time by the chronometer at apparent noon, or when the sun is on the meridian. But if the polar distances A P and D P are unequal, the angles A P Z and D P Z will also be unequal, one of them exceeding half their sum as much as the other is less, D P Z being greater or less than A P Z, according as D P is less or greater than A P, and half the difference of these two angles is the equation of equal altitudes.

Now to compute this equation, let B P = D P, and B Z = D Z or A Z; let A B be part of a parallel of altitude, and B C part of a parallel of declination, and F G the arc of the equator included between P A and P B. Then A C will be the change of the polar distance in the interval measured by A P D; and half F G, or half the angle A P B, will be the required equation. But F G = C B . cosec P B; and as P B C and Z B A are right angles, if the common angle Z B C be taken from each, the remaining angles P B Z and A B C will be equal; and the sides of the triangle A B C being necessarily small, it may be considered as a rectilinear one, right-angled at C.

Hence C B, which is equal to A C . cot A B C, is equal A C . cot P B Z, and therefore $FG = \frac{AC \cdot \cot ZBP}{\sin BP}$; or if A C be seconds of arc, $\frac{FG}{2}$ in *seconds of time* is $\frac{AC \cdot \cot ZBP}{30 \cdot \sin BP}$. Now if d be put for the change of declination from the preceding to the following noon, and T for the time elapsed between the observations, we have $\frac{FG}{2}$

in seconds of time $= \frac{d \,.\, \mathrm{T} \,.\, \cot \mathrm{Z\,B\,P}}{1440 \,.\, \sin \mathrm{B\,P}}$.

By proceeding as in Prop. 21, Spherics, we have $\cos \mathrm{Z\,B\,P} \,.\, \sin \mathrm{Z\,B} + \cos \mathrm{Z\,P\,B} \,.\, \sin \mathrm{Z\,P} \,.\, \cos \mathrm{B\,P} = \cos \mathrm{Z\,P} \,.\, \sin \mathrm{B\,P}$; and as $\sin \mathrm{Z\,B} = \frac{\sin \mathrm{Z\,P} \,.\, \sin \mathrm{Z\,P\,B}}{\sin \mathrm{Z\,B\,P}}$, and $\cot = \frac{\sin}{\cos}$, by substituting and reducing this expression gives $\cot \mathrm{Z\,B\,P} = \frac{\cot \mathrm{Z\,P} \,.\, \sin \mathrm{B\,P} - \cos \mathrm{Z\,P\,B} \,.\, \cos \mathrm{B\,P}}{\sin \mathrm{Z\,P\,B}}$; hence $\frac{\mathrm{F\,G}}{2} = \frac{d \,.\, \mathrm{T} \,.\, \tan \mathrm{lat}}{1440 \,.\, \sin \mathrm{Z\,P\,B}} - \frac{d \,.\, \mathrm{T} \,.\, \tan \mathrm{dec}}{1440 \,.\, \tan \mathrm{Z\,P\,B}}$, and in Tab. 18 $\log \mathrm{A}$ is $\log \frac{\mathrm{T}}{1440 \,.\, \sin \mathrm{Z\,P\,B}}$, and $\log \mathrm{B}$ is $\log \frac{\mathrm{T}}{1440 \,.\, \tan \mathrm{Z\,P\,B}}$; or $\log \mathrm{A} = \log \frac{1}{1440} \,.\, \mathrm{T^h} \,.\, \mathrm{cosect} \frac{\mathrm{T^\circ}}{2}$, and $\log \mathrm{B} = \log \frac{1}{1440} \,.\, \mathrm{T^h} \,.\, \cot \frac{\mathrm{T^\circ}}{2}$.

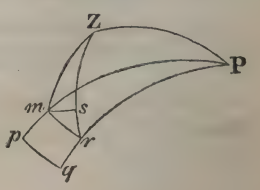
Method of computing the altitude of a celestial object. (See p. 254.)

Let l = the colat, p = the pol dist, a = the zen dist, a' = the alt, and A the object's mer dist.

Then by spherics $\cos \mathrm{A} = \frac{\cos a - \cos l \,.\, \cos p}{\sin l \,.\, \sin p}$; whence $\cos a = \cos l \,.\, \cos p + \sin l \,.\, \sin p - \sin l \,.\, \sin p \,.\, 2 \sin^2 \frac{\mathrm{A}}{2}$, for $\cos \mathrm{A} = 1 - 2 \sin^2 \frac{\mathrm{A}}{2}$. Hence $\cos a = \cos \overline{l \sim p} - \sin l \,.\, \sin p \,.\, 2 \sin^2 \frac{\mathrm{A}}{2}$. Or $\cos^2 \frac{a}{2} = \cos^2 \frac{l \sim p}{2} - \sin l \,.\, \sin p \,.\, \sin^2 \frac{\mathrm{A}}{2}$. Or $\cos^2 \frac{a}{2} = \cos^2 \frac{l \quad p}{2} \left\{ 1 - \sin l \,.\, \sin p \,.\, \mathrm{sect}^2 \frac{l \sim p}{2} \,.\, \sin^2 \frac{\mathrm{A}}{2} \right\} = \cos^2 \frac{l \sim p}{2} \,.\, \cos^2 \mathrm{M}$; if $\sin^2 \mathrm{M} = \sin l \,.\, \sin p \,.\, \mathrm{sect}^2 \frac{l \sim p}{2} \,.\, \sin^2 \frac{\mathrm{A}}{2}$. Hence $\cos \frac{a}{2} = \sin \frac{90^\circ + a'}{2} = \cos \frac{l \sim p}{2} \,.\, \cos \mathrm{M}$.

To find under what circumstances, in a given latitude, a small mistake in observing or correcting the altitude of a celestial object will produce the smallest error in the time computed from it.

Let Z be the zenith, P the pole, r the supposed place, and m the true place of the object. Let $m\,s$ be a parallel of altitude, join the points m and r, and let $p\,q$ be the arc of the equator contained between the meridians Pm and Pr.



Then as Pm and Pr are equal, $m\,r$ may be considered as a small portion of a parallel of declination, $r\,s$ will be the error in altitude, and $p\,q$ the measure of the required

error in time. And as the sides of the triangle $m\,s\,r$ will necessarily be small, that triangle may be considered as a rectilineal one right angled at s; and because the angle P $r\,m$ is also a right angle, the angles $s\,m\,r$ and P r Z, being each the complement of $m\,r\,s$, are equal to each other.

Now we have $r\,s : m\,r ::$ sin $s\,m\,r$ (Z r P) : rad

and $m\,r : p\,q ::$ cos $q\,r$: rad.

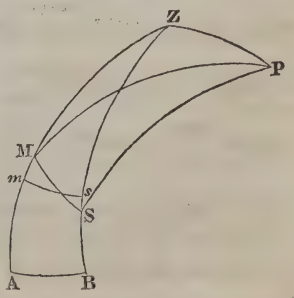
Hence $r\,s : p\,q ::$ cos $q\,r$. sin Z r P : rad^2, or $p\,q = r\,s \cdot \frac{\text{rad}^2}{\cos q\,r \cdot \sin \text{Z}\,r\,\text{P}}$; but sin r P, or cos $q\,r$: sin r Z P :: sin Z P (cos lat) : sin Z r P. Whence cos $q\,r$. sin Z r P = cos lat . sin r Z P, and consequently by substitution we have $p\,q = r\,s \cdot \frac{\text{rad}^2}{\cos \text{lat} \cdot \sin r\,\text{Z}\,\text{P}}$.

Therefore when the latitude and error in altitude are given, the corresponding error in time will be the least when the sine of r Z P, the azimuth, is the greatest; that is, when the azimuth is 90°, or when the object is on the prime vertical. Hence an error in observing or correcting an altitude for the time will be of the least consequence in the result when the object observed is on the prime vertical.

Methods of clearing the distance of the moon from the sun or a star, from the effects of parallax and refraction. (See p. 263.)

Method I.

Let m be the apparent, and M the true place of the moon, s the apparent, and S the true place of the sun; then m A, s B will be the apparent altitudes, m Z, s Z the apparent zenith distances, M A, S B the true altitudes, and M Z, S Z, the true zenith distances; m M will be the correction of the moon's altitude, s S that of the sun's, $m\,s$ the apparent distance, and M S the true distance.



Put $d = m\,s$, D = M S, $h = m$ A, $h' =$ B s, H = M A, H′ = B S. Then (Prop. 18, Spherics,) cos m Z s = cos M Z S $= \frac{\cos m\,s - \cos m\,\text{Z} \cdot \cos s\,\text{Z}}{\sin m\,\text{Z} \cdot \sin s\,\text{Z}} = \frac{\cos \text{M S} - \cos \text{M Z} \cdot \cos \text{S Z}}{\sin \text{M Z} \cdot \sin \text{S Z}}$,

or $\frac{\cos d - \sin h \cdot \sin h'}{\cos h \cdot \cos h'} = \frac{\cos \text{D} - \sin \text{H} \cdot \sin \text{H}'}{\cos \text{H} \cdot \cos \text{H}'}$.

Hence $1 + \frac{\cos d - \sin h \cdot \sin h'}{\cos h \cdot \cos h'} = 1 + \frac{\cos \text{D} - \sin \text{H} \cdot \sin \text{H}'}{\cos \text{H} \cdot \cos \text{H}'}$,

$$\text{or } \frac{\cos d + \cos h \,.\, \cos h' - \sin h' \,.\, \sin h'}{\cos h \,.\, \cos h'} =$$

$$\frac{\cos \mathrm{D} + \cos \mathrm{H} \,.\, \cos \mathrm{H}' - \sin \mathrm{H} \,.\, \sin \mathrm{H}'}{\cos \mathrm{H} \,.\, \cos \mathrm{H}'},$$

$$\text{or } \frac{\cos d + \cos \overline{h + h'}}{\cos h \,.\, \cos h'} = \frac{\cos \mathrm{D} + \cos \overline{\mathrm{H} + \mathrm{H}'}}{\cos \mathrm{H} \,.\, \cos \mathrm{H}'}.$$

Whence,

$$\cos \mathrm{D} = (\cos d + \cos \overline{h + h'}) \,.\, \frac{\cos \mathrm{H} \,.\, \cos \mathrm{H}'}{\cos h \,.\, \cos h'} - \cos \overline{\mathrm{H} + \mathrm{H}'}.$$

$$\text{Put } \frac{\cos \mathrm{H} \,.\, \cos \mathrm{H}'}{\cos h \,.\, \cos h'} = 2 \cos \mathrm{N}.$$

Then $\cos \mathrm{D} = (\cos d + \cos \overline{h + h'}) \,.\, 2 \cos \mathrm{N} - \cos \overline{\mathrm{H} + \mathrm{H}'} = 2 \cos d \,.\, \cos \mathrm{N} + 2 \cos \mathrm{N} \,.\, \cos \overline{h + h'} - \cos \overline{\mathrm{H} + \mathrm{H}'}$.

But (Form. 2, p. 71) $2 \cos d \,.\, \cos \mathrm{N} = \cos \overline{d + \mathrm{N}} + \cos \overline{d \backsim \mathrm{N}}$, and $2 \cos \mathrm{N} \,.\, \cos \overline{h + h'} = \cos (\mathrm{N} + \overline{h + h'}) + \cos (\mathrm{N} \backsim \overline{h + h'})$.

Therefore $\cos \mathrm{D} = \cos \overline{d + \mathrm{N}} + \cos \overline{d \backsim \mathrm{N}} + \cos (\mathrm{N} + \overline{h + h'}) + \cos (\mathrm{N} \backsim \overline{h + h'}) - \cos \overline{\mathrm{H} + \mathrm{H}'}$; or $1 - \cos \mathrm{D} = 1 + \cos \overline{\mathrm{H} + \mathrm{H}'} - \cos \overline{d + \mathrm{N}} - \cos \overline{d \backsim \mathrm{N}} - \cos (\mathrm{N} + \overline{h + h'}) - \cos (\mathrm{N} \backsim \overline{h + h'})$, or $\text{vers } \mathrm{D} = \text{suvers } \overline{\mathrm{H} + \mathrm{H}'} - (1 - \text{vers } \overline{d + \mathrm{N}}) - (1 - \text{vers } \overline{d \backsim \mathrm{N}}) - (1 - \text{vers } (\mathrm{N} + \overline{h + h'})) - (1 - \text{vers } (\mathrm{N} \backsim \overline{h + h'},))$ or $\text{vers } \mathrm{D} = \text{suvers } \overline{\mathrm{H} + \mathrm{H}'} + \text{vers } \overline{d + \mathrm{N}} + \text{vers } \overline{d \backsim \mathrm{N}} + \text{vers } (\mathrm{N} + \overline{h + h'}) + \text{vers } (\mathrm{N} \backsim \overline{h + h'}) - 4$; the formula which, in words, is the first method given for clearing the distance.

Table 25 gives N, and Table 28 gives the *versed* and *suversed* sine of any arc, the first figure being omitted as unnecessary in the solution of this problem; for as d and D cannot, in any case, differ much more than a degree, *vers* D will always be found, either in the same column with *vers* d, or in one of the adjoining columns, and therefore the leading figure in the versed sine can never be required to determine the arc to which *vers* D corresponds.

Method II.

Resuming the equation,

$$\frac{\cos d - \sin h \,.\, \sin h'}{\cos h \,.\, \cos h'} = \frac{\cos \mathrm{D} - \sin \mathrm{H} \,.\, \sin \mathrm{H}'}{\cos \mathrm{H} \,.\, \cos \mathrm{H}'}, \text{ we have}$$

$$1 - \frac{\cos d - \sin h \,.\, \sin h'}{\cos h \,.\, \cos h'} = 1 - \frac{\cos \mathrm{D} - \sin \mathrm{H} \,.\, \sin \mathrm{H}'}{\cos \mathrm{H} \,.\, \cos \mathrm{H}'}, \text{ or}$$

$$\frac{\cos h \,.\, \cos h' + \sin h \,.\, \sin h' - \cos d}{\cos h \,.\, \cos h'} =$$

$$\frac{\cos \mathrm{H} \,.\, \cos \mathrm{H}' + \sin \mathrm{H} \,.\, \sin \mathrm{H}' - \cos \mathrm{D}}{\cos \mathrm{H} \,.\, \cos \mathrm{H}'}, \text{ or}$$

$$\frac{\cos \overline{h \backsim h'} - \cos d}{\cos h \,.\, \cos h'} = \frac{\cos \overline{\mathrm{H} \backsim \mathrm{H}'} - \cos \mathrm{D}}{\cos \mathrm{H} \,.\, \cos \mathrm{H}'}.$$

Whence $\cos \mathrm{D} = \cos \overline{\mathrm{H} \backsim \mathrm{H}'} - (\cos \overline{h \backsim h'} - \cos d) \,.\, \frac{\cos \mathrm{H} \,.\, \cos \mathrm{H}'}{\cos h \,.\, \cos h'}$.

As before, put $\frac{\cos \mathrm{H} \,.\, \cos \mathrm{H}'}{\cos h \,.\, \sin h'} = 2 \cos \mathrm{N}$.

Then $\cos \mathrm{D} = \cos \overline{\mathrm{H} \backsim \mathrm{H}'} - 2 \cos \mathrm{N} \,.\, \cos \overline{h \backsim h'} + 2 \cos \mathrm{N} \,.\, \cos d$, or $\cos \mathrm{D} = \cos \overline{\mathrm{H} \backsim \mathrm{H}'} - \cos (\overline{h \backsim h'} + \mathrm{N}) - \cos (\overline{h \backsim h'} \backsim \mathrm{N}) + \cos \overline{\mathrm{N} + d} + \cos \overline{\mathrm{N} \backsim d}$, or $1 - \cos \mathrm{D} = 1 - \cos \overline{\mathrm{H} \backsim \mathrm{H}'} + \cos (\overline{h \backsim h'} + \mathrm{N}) + \cos (\overline{h \backsim h'} \backsim \mathrm{N}) - \cos \overline{\mathrm{N} + d} - \cos \overline{\mathrm{N} \backsim d}$, or $1 - \cos \mathrm{D} = 1 - \cos \overline{\mathrm{H} \backsim \mathrm{H}'} + 1 + \cos (\overline{h \backsim h'} + \mathrm{N}) + 1 + \cos (\overline{h \backsim h'} \backsim \mathrm{N}) + 1 - \cos \overline{\mathrm{N} + d} + 1 - \cos \overline{\mathrm{N} \backsim d} - 4$, or $\mathrm{vers\ D} = \mathrm{vers}\ \overline{\mathrm{H} \backsim \mathrm{H}'} + \mathrm{suvers}\ (\overline{h \backsim h'} + \mathrm{N}) + \mathrm{suvers}\ (\overline{h \backsim h'} \backsim \mathrm{N}) + \mathrm{vers}\ \overline{\mathrm{N} + d} + \mathrm{vers}\ \overline{\mathrm{N} \backsim d} - 4$.

This formula, in words, gives the second practical method of clearing the distance.

Remark. The method of computing M S directly by spherical trigonometry is obvious; for in the triangle $m\,s\,\mathrm{Z}$, all the sides are given, viz. $m\,s$, the apparent distance, and $m\,\mathrm{Z}$, $s\,\mathrm{Z}$, the apparent zenith distances, to compute the angle $m\,\mathrm{Z}\,s$; and in the triangle M Z S there are given M Z and S Z, the true zenith distances, and the included angle M Z S, before found from the triangle $m\,\mathrm{Z}\,s$, to find M S the true distance.

The computation may be readily made by the following rule deduced from the expressions for $\cos^2 \frac{\mathrm{A}}{2}$, and $\sin \frac{a}{2}$, Propositions XIX and XXII, spherics.

Call half the sum of the true zenith distances arc I, and from half the sum of the apparent zenith distances, and the apparent distance, subtract the apparent distance.

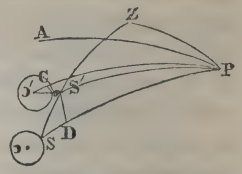
Then add together the *cosects* of the apparent zenith distances, and the *sines* of the half sum, the remainder, and the true zenith distances; reject 40 from the sum, and half the remainder will be the sine of arc II.

Add together the *sines* of the sum and the difference of arcs I and II, and half the sum will be the sine of the true distance.

Take for exercise the examples at p. 269.

Investigation of the method of computing the moon's right ascension from an occultation of a fixed star. (Page 287.)

In the annexed figure let A be the first point of Aries, Z the reduced place of the zenith, ☽ the apparent, and ☽′ the true place of the moon's centre, S the observed, and S′ the true place of the point of occultation, and from S′ draw perps on P S and P ☽′ or on those arcs produced. Then Z P S is the star's mer dist, P S its pol dist, and A P S its right ascension. P ☽′ is the moon's pol dist, S ☽′ her semid, and ☽′ P A her right ascension. S′ P S is arc g in the rule, and S′ P ☽′ is arc h, S D is arc d, ☽′ C is arc f, Z S P is arc c, Z P is l, P S is p, ☽′ P is m, ☽′ S is s, and S S′ is the moon's par in alt.



Now the formulæ for computing arcs a and b are Napier's analogies, investigated at Prop. 21, Spherics, and $S'PS = \frac{S'D}{\sin S'P} =$

$$\frac{S'S \cdot \sin ZSP}{\sin S'P} = \frac{H \cdot \sin ZS \cdot \sin ZSP}{\sin S'P} = \frac{H \cdot \sin ZP \cdot \sin ZPS}{\sin S'P}$$

$$= \frac{H}{\operatorname{cosec} ZP \cdot \operatorname{cosec} ZPS \cdot \sin S'P}. \quad \text{Hence } S'D =$$

$$\frac{H}{\operatorname{cosec} ZP \cdot \operatorname{cosec} ZPS}, \text{ and } SD = \frac{S'D}{\tan S'SD} =$$

$$\frac{H}{\tan S'SD \cdot \operatorname{cosec} ZP \cdot \operatorname{cosec} ZPS}. \quad \text{Lastly } S'P☽ = \frac{S'C}{\sin S'P} =$$

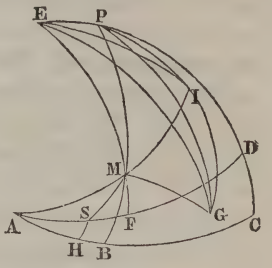
$$\sqrt{\frac{s+f \cdot s-f}{\sin^2 S'P}}.$$ On these formulæ it is only necessary to remark that the sines, &c., in the denominators, are to be added to the proportional logs of the numerators.

If $PD = a$, $DS' = b$, and $PS' = \overline{a + x}$, x being in all cases a small quantity; then $\cos a \cdot \cos b = \cos \overline{a + x} = \cos a - \sin a \cdot \sin x$ nearly.

Whence x in seconds is nearly $= b^2 \cdot \cot a \cdot \frac{\sin 1''}{2}$, the expression from which the table for the correction of e is computed.

USEFUL MISCELLANEOUS NAUTICAL PROBLEMS SOLVED BY THE DIRECT APPLICATION OF SPHERICAL TRIGONOMETRY.

In the annexed figure let A represent the first point of Aries, A D the first quadrant of the ecliptic, E its north pole, A C the first quadrant of the equator, and P its north pole; let S be the place of the sun in the ecliptic, S H a perpendicular from S on A C, and M, I, and G the places of any other celestial objects. Let E M F, P M B be great circles drawn to the ecliptic and equator from the poles E and P, making of course the angles at B and F right angles; and let great circles be drawn, as in the figure from I and G, to E and P. Then D A C, measured by D C, or its equal E P, is the obliquity of the ecliptic; A S is the sun's longitude, A H his right ascension, and S H his north declination; A F the longitude, M F the latitude, M E the co-latitude, A B the right ascension, B M the declination, and M P the polar distance of M; M E I is the difference of longitude, and M P I the difference of right ascension of M and I; M E G is the difference of longitude, and M P G the difference of right ascension of M and G; G E I is the difference of longitude, and G P I the difference of right ascension of G and I.



The first quadrants only of the ecliptic and equator are drawn in the figure; but these circles may be conceived to be produced round the globe, forming two great circles, of which the poles are E and P. The longitudes and right ascensions of celestial objects are reckoned from A, in the direction A D, A C, quite round to A again; the latitude is north when the object and E are on the same side of the ecliptic, and south when they are on different sides; the declination is north when the object and P are on the same side of the equator, and south when they are on different sides.

The figure appropriate to any given problem will be readily conceived by referring the data to a celestial globe.

Problem I.

Given the obliquity of the ecliptic, and the sun's longitude, to find his right ascension and declination.

Here in the spherical triangle A S H, right angled at H, are given A S, and the angle S A H, to find A H and S H.

If the longitude exceed six signs, or 180°, there will be formed on the other side of A C a right-angled spherical triangle, whose base on the equator is the sun's right ascension from ♎, the hypothenuse, on the ecliptic, the sun's distance from ♎, or the excess of his longitude above 180°, the included angle being the obliquity of the ecliptic, and the perpendicular from the sun's place on the equator, the south declination. If 180° be added to the right ascension, computed from ♎, the sum will be the right ascension from ♈.

Examples for Exercise.

The obliquity of the ecliptic being 23° 27′ 50″, it is required to compute the sun's right ascension and declination in each of the following examples?

No.	☉'s Longitude.	☉'s R. A. in Degrees, &c.	☉'s R. A. in Time.	☉'s Declination.
	s ♌ ′ ″	° ′ ″	h m s	° ′ ″
1	1 2 30 8	30 18 14	2 1 12·9	12 21 14 N
2	3 7 49 8	98 30 50	6 34 3·3	23 13 58 N
3	4 7 24 36	129 49 14	8 39 16·9	18 26 14 N
4	7 1 16 31	209 7 34	13 56 30·3	11 55 47 S
5	8 4 28 58	242 30 31	16 10 2·1	21 3 33 S
6	10 10 53 11	313 20 44	20 53 23·0	17 31 8 S
7	11 20 8 44	350 56 47	23 23 47·1	3 54 27 S

Problem II.

From the obliquity of the ecliptic, and the latitude and longitude of any celestial object, to find its right ascension and declination.

Let M (see the last figure) be the object; then in the right-angled spherical triangle A F M are given A F the longitude, and M F the latitude, to find A M the distance of the object from ♈, and the angle M A F. The sum or difference of M A F and F A B is M A B; and in the right-angled triangle M A B there are then given A M and M A B, to find A B the right ascension, and B M the declination.

Or, in the triangle M E P are given E P, the obliquity of the ecliptic, E M the co-latitude, and M E P the co-longitude of M, to find M P the polar distance, and E P M the supplement of M P C, the co-right ascension.

Examples for Exercise.

The obliquity of the ecliptic being 23° 27′ 50″, it is required to compute the right ascensions and declinations of the objects whose latitudes and longitudes are given in the following examples?

No.	Longitude.	Latitude.	R. A. in Degrees, &c.	R. A. in Time.	Declination.
	s ° ′ ″	° ′ ″	° ′ ″	h m s	° ′ ″
1	2 18 18 31	3 21 32 N	76 57 33	5 7 50·2	26 17 39 N
2	10 3 38 28	0 32 36 N	305 49 25	20 23 17·7	18 49 51 S
3	4 11 14 4	1 14 14 S	133 20 32	8 53 22·1	16 14 2 N
4	7 22 17 30	4 49 0 S	228 32 2	15 14 8·1	23 0 43 S
5	1 21 16 9	4 50 57 N	47 27 32	3 9 50·1	22 46 15 N
6	8 9 25 14	5 28 14 S	246 48 46	16 27 15·1	27 17 28 S
7	6 21 15 20	30 13 28 N	211 12 15	14 4 49·0	19 41 47 N

Note. By the two preceding problems the right ascensions and declinations of the sun and moon, in the Nautical Almanac, are computed.

Problem III.

From the longitude of the sun, and the latitude and longitude of any other celestial object, to find the distance of that object from the sun.

Let S (see the last figure) be the sun, and M the other object; then in the spherical triangle S F M, right angled at F, are given M F, the latitude of the object, and S F, the difference of longitude of the object and the sun, to compute S M, the required distance.

Examples for Exercise.

It is required to compute the true distance between the sun and the moon, or a star, in each of the following examples?

No.	☉'s Longitude.	☽ or ✳'s Longitude.	☽ or ✳'s Latitude.	Distance.
	s ° ′ ″	s ° ′ ″	° ′ ″	° ′ ″
1	11 8 37 49	9 5 32 48	4 55 0 S	63 11 26
2	10 19 59 40	1 14 40 41	4 33 48 N	84 42 2
3	1 3 56 52	9 23 36 1	3 51 10 S	100 19 26
4	2 18 43 17	6 14 17 0	2 57 46 S	115 31 31
5	4 11 42 2	6 24 20 24	3 59 56 S	72 40 59

Note. By this problem the distances of the sun and moon, in the Nautical Almanac, are computed.

Problem IV.

From the latitudes and longitudes of any two celestial objects, to find their distance.

Let M and I (see the last figure) be the two objects, then in the spherical triangle M I E are given the two sides M E, I E, the

co-latitudes of the given objects, and the included angle M E I, the difference of their longitudes, to find I M, their distance.

Note. The co-latitudes of the objects are estimated from the same pole of the ecliptic.

Examples for Exercise.

In each of the following examples, A and B are two stars, from whose latitudes and longitudes it is required to compute their distance?

No.	A		B		Distance.
	Longitude.	Latitude.	Longitude.	Latitude.	
	s ° ′ ″	° ′ ″	s ° ′ ″	° ′ ″	° ′ ″
1	3 2 4 40	38 40 26 N	9 11 41 26	13 26 11 N	127 7 11
2	11 14 28 26	26 14 37 S	1 3 45 30	30 28 45 S	43 14 18
3	4 23 18 46	12 29 40 N	6 1 20 13	25 7 16 S	52 48 24
4	6 14 46 0	10 14 0 N	8 20 15 0	18 20 0 S	70 37 30

Note. By this or the following problem the distances of the moon from the fixed stars and planets, in the Nautical Almanac, are computed.

Problem V.

From the right ascensions and declinations of any two celestial objects, to find their distance.

Let M and I, as in the last problem, represent the two objects; then in the spherical triangle M P I are given M P and P I, the polar distances of the objects, and M P I, the difference of their right ascensions, to find M I, their distance.

Examples for Exercise.

In each of the following examples, A and B are two stars, from whose right ascensions and declinations their distance is to be computed?

No.	A		B		Distance.
	Right Ascension.	Declination.	Right Ascension.	Declination.	
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
1	146 14 28	16 28 4 S	70 36 40	14 40 26 N	80 53 3
2	182 4 40	14 26 20 S	133 8 26	16 30 5 N	57 22 36
3	30 50 14	28 14 35 N	98 22 7	36 2 8 N	56 35 20
4	120 18 4	4 30 16 N	200 7 4	7 12 24 S	80 30 9
5	30 40 26	18 40 20 N	359 11 29	23 17 36 N	29 41 47

Problem VI.

The distance of an unknown star, or comet, from two known stars being given, to find its right ascension and declination.

Let G (see the last figure) be the unknown star or comet, and M, I, the two known stars whose distances M G, I G, from G are given;

then from M P, P I, and M P I, the distance M I of the two known stars may be found, as in the last problem, and in the same triangle the angle P M I may be found. In the triangle I M G all the sides are given to find the angle G M I, the sum or difference of which and P M I is P M G. Then P M, M G, and the contained angle P M G are given to compute P G the polar distance, and M P G the difference between the right ascensions of G and M; whence, as the right ascension of M is known, that of G is also known.

Note. The observed distances should be cleared from the effects of refraction, which may easily be done by Spherics, according to the methods pointed out in the "*Remark*" at p. 299.

Examples for Exercise.

1. If on November 14, 1836, the distance of a comet from Marcab be 42° 14′, and from Altair 36° 35′, northward from the stars, required its right ascension and declination?

Answer, right ascension 308° 13′ 49″, declination 43° 20′ 53″ N.

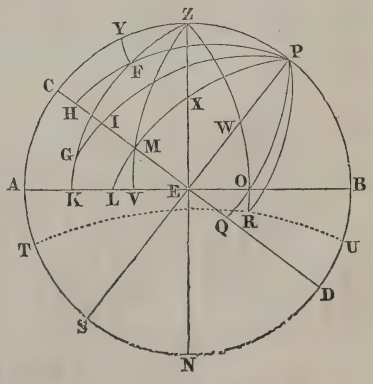
2. If on February 5, 1850, the distance of a star from Rigel be 36° 58′ 20″, and from Procyon 34° 15′ 20″, southward from the stars, required its right ascension and declination?

Answer, right ascension 109° 47′ 18″, declination 28° 31′ 18″ S.

3. If on March 14, 1840, the distance of an unknown star from Spica be 26° 50′ 50″, and from Antares 32° 18′ 40″, southward from the stars, required its right ascension and declination?

Answer, right ascension 208° 42′ 56″, declination 35° 44′ 27″ S.

Let the annexed figure represent the celestial sphere, A Z B N A being the meridian of an observer whose zenith is Z, and nadir N. Let P be the north, and S the south pole, and let A Z, B Z, P C, and P D be quadrants. Then the eye in viewing the figure being conceived to be vertically over E, the point on the surface which is the apparent centre of A Z B N A, all great circles, as A B, C D, P S, Z N, drawn through E will appear in the figure as straight lines; A B will represent the rational horizon, C D the equator, Z N the prime vertical, and P S the six o'clock hour circle, or the hour circle at right angles to the meridian. The great circles drawn through Z will be perpendicular to



A B, and those drawn through P will be perpendicular to C D. C Z = P B = N D = A S, is the latitude, and Z P = B D = S N = A C, the co-latitude of the observer, whose zenith is Z; the arcs measuring their corresponding angles at the apparent centre E, or the spherical angles on the surface of the sphere at E. F K is the altitude of an object at F, F Z its zenith distance, F H its north declination, F P its polar distance, F P Z its meridian distance, F Z P its azimuth from the north, and F Z C its azimuth from the south. G K is the altitude of an object at G, G Z its zenith distance, G I its south declination, G P its polar distance, G P Z its meridian distance, G Z P its azimuth from the north, and G Z C its azimuth from the south. F P G is the difference of the meridian distances or of the right ascensions of F and G; C Q, the measure of Z P O, is the semidiurnal arc of an object which rises or sets at O; and E Q, the complement of C Q, is the ascensional difference of O, or the measure of the time between its rising or setting and passing the six o'clock hour circle; E O is the amplitude of O, and E L the amplitude of L; T U, a small circle parallel to A B, and 18° below it, is the twilight circle, or that on which the sun is at the beginning and end of twilight.

Problem VII.

Given the declination of a celestial object, to find its altitude and bearing when on the six o'clock hour circle in a given latitude.

In this problem the latitude and declination must be of the same denomination, otherwise the object will pass the six o'clock hour circle before it rises.

In the triangle E W O (see the last figure) right-angled at O, are given E W the declination, and W E O the latitude, to find W O the altitude, and E O the bearing from the prime vertical, southward or northward, according as the latitude is south or north.

Examples for Exercise.

In each of the following examples it is required to compute the altitude of the object, and its bearing from the east or west, when on the six o'clock hour circle.

No.	Latitude.	Declination.	Altitude.	Bearing from E or W.
	° ′	° ′	° ′	° ′
1	48 21 N	10 4 N	7 30	6 44 N
2	59 16 N	23 14 N	19 49	12 22 N
3	30 28 S	4 5 S	2 4	3 31 S
4	14 29 N	16 38 N	4 6	16 8 N
5	17 28 N	12 40 N	3 46	12 6 N

Problem VIII.

Given the declination of a celestial object, to find its altitude and meridian distance, when on the prime vertical, in a given latitude.

In this problem also the latitude and declination must be of the same name. Let X (see the last figure) be the object on the prime vertical Z E, then in the triangle E M X, right-angled at M, are given M X the declination, and M E X the latitude, to find X E the altitude, and M E the complement of M C the meridian distance, whence M C is determined. Or in the triangle X P Z, right-angled at Z, are given X P the object's polar distance, and Z P the co-latitude, to find Z P X the meridian distance, and Z X the zenith distance, whence the altitude E X is known.

Examples for Exercise.

In each of the following examples the altitude of the object when on the prime vertical, and its meridian distance at the time, are required?

No.	Latitude.	Declination.	Altitude.	Meridian Distance in Time.
	° ′	° ′	° ′	h m s
1	48 26 N	20 5 N	27 19	4 44 20
2	50 3 S	12 28 S	16 21	5 17 20
3	30 29 N	9 41 N	19 22	4 52 36
4	56 18 N	20 5 N	24 23	5 3 32
5	27 42 S	18 4 S	41 51	3 26 20

Problem IX.

To find the semidiurnal arc, or the time between a known celestial object's rising or setting, and its passing the meridian, neglecting the effects of dip, refraction, and parallax.

Let O (see the last figure) be the object at rising or setting; then in the quadrantal triangle O P Z, are given O Z a quadrant, Z P the co-latitude, and O P the object's polar distance, to find Z P O, the angle whose measure is the semidiurnal arc. Or in the triangle E Q O right-angled at Q, are given Q E O the co-latitude, and Q O the declination, to find E Q, the time between the object's rising or setting, and its passing the six o'clock hour circle; and the sum or difference of E Q and six hours, according as the latitude and declination are of the same or different names, is the semidiurnal arc.

By this problem the time of the sun's rising and setting, and the length of the day are found; for the semidiurnal arc shows the time of setting, and deducted from twelve hours, leaves the time of rising;

and the semidiurnal arc of any object, added to the time of its passing the meridian, shows the time of its setting; and, subtracted, shows the time of its rising.

When the declination is equal to or exceeds the co-latitude the object will be always above, or always below the horizon of the place, according as the declination and latitude are of the same or of contrary denominations.

Examples for Exercise.

In each of the following examples the semidiurnal arc is required?

No.	Latitude.	Declination.	Semidiurnal Arc in Time.
	° ′	° ′	h m s
1	58 12 N	18 40 S	3 47 56
2	34 16 N	26 18 N	7 18 44
3	20 45 S	30 12 S	6 50 57
4	49 3 S	9 36 N	5 15 2
5	36 28 N	14 20 N	6 43 32

Problem X.

To find the apparent time at which the sun's centre rises and sets at a given place, on a given day, allowing for the effect of dip, refraction, and parallax.

If from the sum of the dip and the horizontal refraction the sun's parallax be subtracted, the remainder, added to 90°, will be his distance from the zenith when his centre *appears* on the horizon. Hence, in an oblique angled triangle, as O Z P, we have O Z the corrected zenith distance, O P the polar distance, and Z P the co-latitude, given to compute Z P O the meridian distance, or the time from noon at which his centre rises or sets.

Note. The declination used in the computation should be that which the sun has at the time of rising or setting. If therefore the semidiurnal arc be computed from the declination at the noon of the given day, by the last problem, the approximate time of rising or setting may be found from it; and thence, by applying the longitude, the corresponding Greenwich time will be obtained. The declination may then be corrected for that time, and the true time of rising or setting found as above.

Examples for Exercise.

In each of the following examples the apparent time at which the sun's centre rises and sets is required?

No.	Date.	Latitude.	Long.	Height of the Eye.	Time of rising.	Time of setting.
		° ′	°	feet.	h m s	h m s
1	May 4, 1823	33 28 N	40 W	16	5 13 53 A.M.	6 46 36 P.M.
2	Oct. 11, 1824	57 2 N	6 E	12	6 39 12	5 19 43
3	Sept. 5, 1839	46 20 N	25 W	20	5 26 23	6 32 39
4	April 20, 1850	38 4 S	17 E	13	6 33 9	5 26 21
5	Aug. 19, 1834	60 28 N	20 W	15	4 18 31	7 39 47

Problem XI.

Given the latitude and the sun's declination, to find the beginning and end of twilight.

In the last figure, let R be the place of the sun on the twilight circle; then in the triangle R Z P are given R Z 108°, R P the sun's polar distance, and Z P the co-latitude of the observer, to find Z P R, the time from noon when twilight begins or ends.

Remark. If the latitude and the sun's polar distance differ only 18°, or less, there will be continual twilight while the sun is below the horizon.

Examples for Exercise.

In each of the following examples the times of the beginning or the end of twilight are required?

No.	Latitude.	Sun's Declination.	Beginning of Twilight.	End of Twilight.
	° ′	° ′	h m s	h m s
1	56 28 N	16 37 S	5 29 19 A.M.	6 30 41 P.M.
2	48 57 N	14 28 N	2 34 9	9 25 51
3	29 14 S	20 12 S	3 37 17	8 22 43
4	50 28 N	13 4 N	2 35 6	9 24 54
5	60 17 N	0 0	3 25 44	8 34 16

Problem XII.

Given the altitude of a known star, when another known star is on the same vertical with it, to find the latitude.

Let G and F (see the last figure) be the places of the two stars, G being that whose altitude G K, or zenith distance G Z, is given. Then, in the triangle G P F, are given G P and P F, the polar distances, and G P F the difference of the right ascension of the two stars, to find the angle P G F; and in the triangle Z G P are then given Z G and P G, the zenith distance and polar distance of G, and the included angle Z G P, to find Z P the co-latitude C.

Examples for Exercise.

In each of the following examples the true latitude s required?

No.	Date.	Star whose Alt. is obsvd.	Observed Altitude.	Star on the same Vertical.	Height of the Eye.	Latitude by Acct.	True Latitude.
			° ′		feet.	°	° ′
1	Mar. 5, 1840	Spica	15 28 +	Regulus	15	20 N	19 56 N
2	April 4, 1830	Sirius	26 30 —	Procyon	18	38 N	37 18 N
3	Dec. 4, 1830	Aldebaran	31 2 +	Menkar	20	14 S	13 10 S
4	Feb. 19, 1850	Rigel	28 7 —	Castor	16	39 N	38 49 N

Problem XIII.

Given the meridian distance of a known celestial object and its altitude, to find the latitude.

Let F (see the last figure) be the place of the object; then, in the triangle Z P F are given F P the polar distance, F Z the zenith distance, and Z P F the meridian distance of F, to find Z P the co-latitude; an example of the *ambiguous* case in spherics. Let F Y be a perpendicular from F on P Z, or P Z produced; then cot F P : rad :: cos Z P F : tan P Y; and cos F P : cos P Y :: cos F Z : cos Z Y. The sum or difference of P Y and Z Y is P Z the co-latitude; and from the latitude by account it will generally be obvious whether the sum or the difference ought to be taken.

It will be found advisable, in practice, to apply this problem only when the object is near the meridian, as a small mistake in the apparent time may, under other circumstances, produce a considerable error in the result.

If the object be the sun, the apparent time, or the difference between the apparent time and twenty-four hours, is his meridian distance; in the case of a star, the difference between its right ascension and the right ascension of the meridian, is its meridian distance.

Examples for Exercise.

In each of the following examples the true latitude is required?

No.	Date.	Apparent Time.	Object Observed.	Observed Altitude.	Height of Eye.	Lat. by Acct.	Long. by Acct.	True Latitude.
		h m s		° ′	feet	°	°	° ′
1	July 5, 1824	11 4 26 A.M.	☉	61 20 +	14	50 N	12 W	49 4 N
2	Oct. 29, 1825	0 30 14 P.M.	☉	20 39 —	20	55 N	20 W	55 24 N
3	Aug. 5, 1848	0 21 40 P.M.	☉	50 34 —	18	22 S	4 E	22 0 S
4	May 11, 1854	9 11 34 P.M.	Spica	55 56 +	15	42 S	80 E	42 29 S
5	Sept. 6, 1840	0 20 20 A.M.	Fomalhaut	7 14 —	21	52 N	9 W	52 14 N

Problem XIV.

From the altitude of two known stars, observed at the same instant, to find the latitude.

In the figure, p. 297, let S and M represent the true places of the stars; then, in the triangle M P S, are given M P, P S the polar distances, and M P S the difference of the right ascensions of the two stars, to find their distance M S, and the angle P S M; and in the triangle M S Z there are then given M Z, S Z the true zenith distances of the stars, and M S their distance, to find the angle Z S M; the difference between which and P S M is Z S P. Hence there are given Z S and S P, the zenith distance and polar distance of S, and the included angle Z S P, to find Z P the co-latitude.

If one of the altitudes be increasing and the other decreasing, Z will fall between S P and M P; and if Z and P are on different sides of M S, the sum of M S P and Z S M will be Z S P; but this may be avoided in practice, by selecting two stars whose polar distances are greater than the co-latitude.

If the altitudes cannot both be obtained at the same instant, add the interval between the observations, reduced into sidereal time, (by adding one second for every six minutes,) to the right ascension of the star first observed, and the sum will be its reduced right ascension, with which, the altitude and polar distance of the star, and the altitude, right ascension, and polar distance of the other star, make the computation as above.

Examples for Exercise.

The latitude is required in each of the following examples, the altitudes of both stars being taken at the same time?

No.	Date.	Easterly Star.	Observed Altitude.	Westerly Star.	Observed Altitude.	Height of Eye.	Lat. by Acct.	True Lat.
						feet.		
1	Nov. 16, 1843	α Arietes	43 5 +	Marcab	60 15 +	30	44 N	43 45 N
2	Jan. 4, 1830	Procyon	69 50 +	Rigel	46 3 −	20	25 N	24 58 N
3	Oct. 20, 1846	Aldebaran	56 58 +	Pollux	30 5 +	18	41 N	40 20 N
4	Jan. 5, 1840	Regulus	32 40 +	Rigel	30 50 −	16	49 N	48 34 N
5	Mar. 5, 1835	Spica	53 55 −	Regulus	10 5 −	20	45 S	44 51 S

In each of the following examples, the altitudes of two stars, and the interval between the observations, are given to find the latitude.

No.	Date.	First Star observed.	Observed Altitude.	Second Star observed.	Observed Altitude.	Interval.	Height of Eye.	Lat. by Acct.	True Lat.
						m s	feet.		
1	May 15, 1837	Altair	23 40 +	Antares	25 7 +	7 20	20	38 N	37 35 N
2	Dec. 29, 1848	Marcab	30 40 −	α Arietes	58 7 −	6 4	14	53 N	52 50 N
3	Feb. 14, 1850	Procyon	33 5 −	Rigel	33 10 −	8 28	16	52 S	50 58 S

Problem XV.

From the observed altitude and angular distance of the sun and moon on a given day, to find both the latitude and longitude of the place of observation.

Take from the Nautical Almanac the sun's semidiameter for the given day, and the semidiameter and horizontal parallax of the moon for the hour which corresponds most nearly with the given distance, and correcting the altitudes and distance for semidiameter, &c. clear the distance in the usual manner from the effects of parallax and refraction, and find from the Nautical Almanac the Greenwich time which corresponds to it. If this time differ much from the time before taken, let the semidiameter and parallax of the moon be taken out for the time thus found, the distance recomputed, and the corrected time at Greenwich found from it; for which time also let the declinations of the sun and moon be taken, and thence their polar distances found. Then, in the figure, p. 297, S and M representing the true places of the sun and moon, P the pole, and Z the zenith; in the triangle M Z S are given M Z and S Z the true zenith distances, and M S the true distance of the objects, to find the angle M S Z; and in the triangle P M S are given P M and P S the polar distances of the objects, and M S their true distance, to find the angle M S P, the difference between which and M S Z is P S Z; and in the triangle Z S P there are then given Z S and P S, the zenith distance and polar distance of the sun, and the included angle Z S P, to find Z P the co-latitude, and Z P S the sun's meridian distance, whence the apparent, and consequently the mean time at the place of observation is known; and, as the mean time at Greenwich at the same instant is found from the distance, the difference of those times, or the longitude in time is known.

Note. If S were the place of *a star*, the latitude and the star's meridian distance, would be found as above; and from the star's meridian distance, its right ascension, and the right ascension of the sun, the apparent and thence the mean time at the place of observation, whence, as above, the longitude might be found.

Examples for Exercise.

1. If in N latitude the altitude of ☉ be 26° 48′ +, and of ☽ 72° 10′+, when the distance of their nearest limbs is 53° 32′ 40 on September 29, 1823, height of the eye 20 feet, required the latitude and longitude?

Answer, latitude 32° 44′ N, and longitude 32° 38′ E

2. On September 8, 1823, in N latitude, the altitude of ☉ was 26° 50′ —, and of ☽ 31° 30′ —, distance of their nearest limbs 47° 25′ 49″, height of the eye 26 feet; required the latitude and longitude? Answer, latitude 37° 50′ N, and longitude 19° 20′ E.

PROMISCUOUS QUESTIONS FOR EXERCISE.

1. Given the sun's declination 3° 16′ 6″ S +, and right ascension 12h 30m 14·4s, required his longitude and the obliquity of the ecliptic?

Answer, longitude 6s 8° 13′ 57″, and obliquity 23° 27′ 46″.

2. In latitude 40° 48′ N, the sun bore S 79° 16′ W, at 3h 37m 59s. P. M.; required his altitude and declination?

Answer, altitude 37° 24′, and declination 16° 32′ N.

3. In N latitude, when the sun's declination was 14° 20′ N, his altitudes, at two different times, on the same forenoon, were 43° 7′ +, and 67° 10′ +, and the change of his azimuth in the interval 45° 2′; required the latitude? Answer, 34° 20′ N.

4. In latitude 16° 4′ N, when the sun's declination is 23° 2′ N, required the time in the afternoon, and the sun's altitude and bearing, when his azimuth neither increases nor decreases?

Answer, time 3h 9m 26s P. M., altitude 45° 1′, and bearing S 73° 16′ W.

5. The sun set S W ½ S, when his declination was 16° 4′; required the latitude? Answer, 69° 1′,

6. The altitude of the sun, when on the equator, was 14° 28′ +, bearing E S E; required the latitude and time?

Answer, latitude 56° 1′, and time 7h 46m 12s A. M.

7. The altitude of the sun was 20° 41′, at 2h 20m P. M., when his declination was 10° 28′ S; required his azimuth and the latitude?

Answer, azimuth S 37° 5′ W, latitude 51° 58′ N.

8. If, on August 11, 1840, Spica set 2h 26m 14s before Arcturus height of the eye 15 feet, required the north latitude?

Answer, 36° 46′ N.

9. If, on November 14, 1829, Menkar rise 48m 3s before Aldebaran, height of the eye 17 feet, required the north latitude?

Answer, 39° 43′ 30″ N.

10. If, on January 4, 1825, Castor and Alphard be observed on the same vertical in the eastern hemisphere, at the same time that Betelgeuse and Rigel are on the same vertical in the western hemisphere, required the N latitude? Answer, 35° 12′ N.

11. In latitude 16° 40′ N, when the sun's declination was 23° 18′ N, I observed him twice, in the same forenoon, bearing N 68° 30′ E; required the times of observation, and his altitude at each time?

Answer, times 6h 15m 40s A. M. and 10h 32m 48s A. M., altitudes 9° 59′ 36″ and 68° 29′ 42″.

PROBLEMS REQUIRING THE USE OF A TRANSIT INSTRUMENT.

A TRANSIT instrument is a telescope which revolves in the plane of the meridian on a horizontal axis; and it has in its focus generally five wires, but sometimes only three; the middle one in the plane of the meridian, and the others parallel to and equidistant from it; and the mean of the times at which a celestial object is observed on each wire, is the instant of its being on the meridian, if the time by the clock be correct.

This is one of the capital instruments in an observatory, as, with it and a sidereal clock, the right ascensions of all celestial objects are determined: for *when an object is on the meridian, the sidereal time at the place of observation is that object's right ascension.*

From their resemblence to the letter Y, the sockets, in which the horizontal axis revolves are called Ys.

Portable instruments of this kind have of late been much used by persons engaged in extensive nautical and geodetic surveys, to determine the longitudes of important points, and the errors and rates of chronometers.

The principal adjustments of this instrument are, to level the axis, to place the middle wire perpendicular to the horizon, and the line of collimation, or the line of sight, perpendicular to the horizontal axis. For making these adjustments, the following directions, drawn up by Capt. Kater, for the use of the officers engaged in the Polar expeditions, may suffice.

'Slide the eye-piece in or out till the wires are seen distinctly. Direct the telescope to some distant and well defined object, and turn the milled head on the side of the transit till the object is seen with perfect distinctness. Place the level on the axis, and bring the bubble to the middle by the screw which elevates or depresses one of the Ys. The axis of the transit will then be parallel to the horizon.

'Having brought the object to the central vertical wire by means of the screws which act horizontally on one of the Ys, observe whether the same part of the object is covered by the wire while the telescope is elevated or depressed, and if not, correct half the apparent deviation by turning round the cell which contains the wires.

'The middle wire covering some well-defined distant object, take the instrument out of the Ys, and carefully invert it, when, if the wire no longer covers the same part of the object, correct half the error by means of the screws which act horizontally upon the wires, and the remaining half by the screws which act horizontally upon the Ys. Repeat this operation till the vertical wire covers the same part of

the object in both positions of the telescope, and the line of sight will then be perpendicular to the axis.'

These adjustments may be supposed to be made with the telescope *nearly* in the plane of the meridian. To bring it *exactly* so, find the *time* at which any star will be on the meridian, and at that instant, by means of the screw acting horizontally on one of the Ys, make the middle wire bisect the star; repeat the operation with several stars, until you are satisfied that the adjustment is perfect.

For further information on the use of this and other astronomical instruments, see Dr. Pearson's large work on Practical Astronomy, and a most valuable little work on Astronomical and Surveying Instruments, by Mr. F.W. Simms, late of the Royal Observatory, Greenwich, a second and enlarged edition of which has just appeared.

Problem I.

To find the longitude on land, from the interval between the sidereal times of the transit of the moon's bright limb and a fixed star, the corresponding interval being observed at, or computed for a known meridian.

Note. In practice the stars observed are such only as differ but little in right ascension and declination from the moon. A list of such (called "moon culminating stars") as are proper to be observed with the moon for this purpose, is now given in the Nautical Almanac, for every day on which the moon can be seen. The right ascensions of the stars, and of the moon's bright limb at the instant of passing the meridian of Greenwich, are also given with all practicable accuracy,—so that if the intervals are not *observed* at Greenwich, the difference of the right ascensions of the star and the moon's bright limb, as given in the Nautical Almanac, may be taken as the Greenwich interval. And if the star is one whose place is well determined, the Greenwich interval so obtained, will in general be little, if at all, inferior, in point of accuracy, to one deduced from actual observation.

With respect to the principle of this method of finding the longitude, it is evident, that if the moon had no motion in right ascension, and her declination and semidiameter did not change, the *interval* between the times of transit of her limb and the star, will be the same at both places,—and that, presuming motion in right ascension only, the difference of the intervals would arise from and be equal to the increase of her right ascension in the time between the limb's passing the two meridians, or after the easterly meridian's passing the limb the westerly one would have to revolve through one angle equal to the sum of the difference of longitude and the increase of the moon's right ascension before it would reach the same limb.

If therefore D = the diff long, I = the mean increase, in time, of the moon's right ascension in a sidereal hour, and I′ the observed increase of her right ascension in the time between her passing the two meridians, then $I : 1^h :: I' : D + I'$; whence $I : 1^h - I :: I' : D$ or

$$D = \frac{1^h - I}{I} \cdot I'$$

We have seen that the moon's declination and semid. being constant, I′ is the difference of the sidereal interval between the transits of the moon's bright limb and a star, at the two meridians. But if the declination and semid. be not the same at both times of observation, a correction for the change must be applied to one of the intervals before their difference will accurately represent the required increase of the moon's right ascension.

The effect in seconds of time of a change in the declination may be computed with sufficient accuracy by the first of the following formulæ, and that of a change in the semid. by the second.

1. $\text{cor} = 2\,S \cdot \tan \overline{d + \frac{d'}{2}} \cdot \sec \overline{d + \frac{d'}{2}}$

2. $\text{cor} = S' \cdot \sec d \cdot \cdot 069$

Where d is the declin., d' its change; S the moon's semid. in seconds of time, and S′ its change in seconds of arc.

The following table, computed from the first of these formulæ, (to the mean semid. of the moon,) gives the effect of a change of 1° in the declin.; and the effect of any other change is found by multiplying the tabular correction for 1°, by the degrees and parts of a degree in the given change. The Table is entered with the mean of the moon's declinations at the times of observation. Thus if the declinations are 10° 40′ and 13° 10′, the mean is 11° 55′, corresponding to which in the Table is ·234s; which multiplied by 2·5° the change of declination, gives ·587s for the correction.

The extreme deviation from the moon's mean semidiameter, to which the table is adapted, will scarcely ever affect this correction in the second place of decimals; what the moon's actual semidiameter is at the time, is, therefore, of no importance.

From Table 34, which is computed from the second of the preceding formulæ, the effect of a change in the moon's semidiameter may be taken by inspection. Parts of correction for tenths of seconds in the change of the moon's semid. are obtained by taking the tenth part of the correction for the corresponding second.

Table.

Effect of a change of 1° in the moon's declination on the interval between the transits of her limb and a star.

Mean declin.	Cor.	Mean declin.	Cor.	Mean declin.	Cor.	Mean declin.	Cor.
°	s	°	s	°	s	°	s
0	·000	7	·134	14	·278	21	·445
1	·019	8	·154	15	·300	22	·472
2	·038	9	·173	16	·323	23	·499
3	·057	10	·194	17	·346	24	·527
4	·076	11	·214	18	·368	25	·557
5	·095	12	·235	19	·394	26	·587
6	·114	13	·256	20	·419	27	·619
7	·134	14	·278	21	·445	28	·652

Table 33, contains the log of $\frac{1^h - I}{I}$; but the *argument* of the Table is the moon's average change of right ascension in an hour of mean time, obtained by dividing the difference of the right ascensions taken from the Nautical Almanac, for the estimated Greenwich time of the two observations, by the hours, &c. in the difference of those times.

This argument may be found with less trouble, and with sufficient accuracy, if the right ascensions be taken for the nearest approximate times that have the *minutes* of their difference 6, or a multiple of 6; as the number to be divided by will not then have more than one place of decimals.

This being premised, the diff long between the two places may be found by the following

Practical Rule.

Correct the intervals for the rate of the clock or chronometer, adding the part of the daily rate due to each interval, if the rate is a losing, and subtract it if it is a gaining one.

Find the Greenwich time of the moon's transit at both meridians by Prob. 12, p. 222; and if the western limb is observed, subtract 1 minute from each time; but if the eastern limb is observed, add 1 minute to each time, and the result will be the approximate Greenwich time of the transits of the limb.

For these times take the moon's right ascension from the Nautical Almanac, and divide the difference of right ascension by the hours, &c. in the difference of the Greenwich times, and the quotient will be the *mean hourly change of the moon's* right ascension in the interval, or *the argument for Tab.* 33.

Take also the change of declination in the interval, and the declination at the middle time, (which may be both taken roughly by the eye

from the Almanac,) and with them, by the aid of the above table, find the correction of the interval for the change of declination.

By Tab. 34, find also the correction of the interval for the change of the moon's semidiameter.

Then apply these two corrections to the interval at the more *westerly* meridian, with the sign as directed below.

Signs of correction for change of ☽'s declination.

			Correction	
☽'s declin *increasing*	☽ precedes ✳	W limb obs	+	The contrary signs when the declin is *decreasing*.
		E	−	
	☽ follows ✳	W	−	
		E	+	

Signs of correction for change of ☽'s semidiameter.

			Correction	
☽'s semid *increasing*	☽ precedes ✳	W limb obs	−	The contrary signs when the semid is *decreasing*.
		E	+	
	☽ follows ✳	W	+	
		E	−	

Call the seconds in the difference of the corrected intervals, A, or if several stars have been observed, call the seconds in the mean of all the differences of the corresponding intervals A.

Add the logarithm of A *to the logarithm from Table* 33, *corresponding to the argument for that Table already found, and the sum will be the logarithm of the difference of longitude, in seconds of time.*

Note. The parts for hundredths in Table 33 are found in the column of 'parts' opposite the corresponding tenths. Thus, for 1m 42·57s, the log for 1m 42·5s is 1·534256, and the part for 7 hundredths is ·304; whence the log is 1·533952. Striking off the figures on the right in the column of 'parts,' the remaining figures on the left are parts for thousandths.

If either of the intervals is in mean time, from its 360th part subtract the 70th part of that part, and the remainder added to the interval in mean time will give it in sidereal time. If both intervals are in mean time, reduce their difference to sidereal time by the same rule.

If the moon precede the star at the easterly, and follow it at the westerly meridian the *sum* of the intervals, instead of their *difference*, will be A.

Example.

If on October 18th, 1836, η Capricorni pass the meridian of Greenwich at 20h 55m 6·31s and the moon's W limb at 21h 9m 3·37s sidereal time; and on the same day on long by estimation 50° W, the corresponding times were 11h 12m 40·74s and 11h 34m 51·23s, by a chronometer gaining on mean time 8·4s per day, required the true longitude.

By the Nautical Almanac.		☽'s R A			☽'s Dec
	h m m	h m	h m	s	
☽'s mer pass	7 21+54	7 20,	21 10	12·56	21° 50′ Diff ·63°
Deduct 1m for W limb .	1	10 47,	21 18	26·40	21 12
Approx time of trans limb	7 20	Diff	8 13·84		21 31 Mean
Long in time+cor, Tab 17	3 27=3·45h				
Green Time of W transit .	10 47		m s		
		8 13·84			=2, 23·16 ☽'s hourly inc of R A
		3·45			

Decrease of ☽'s semid in 3h 27m, ·6″.

Greenwich Time.			Chronometer Time at W station.		
	h m	s	h m	s	
	20 55	6·31	11 12	40·74	
	21 9	3·37	11 34	51·23	
Interval	13 57·06		22 10·49		
		Cor for rate	−13		
Interval in mean time . . .			22 10·36		
Red. to sid. time			+ 3·64		
Interval in sid. time . . .			22 14·00		
Correction for ch. of dec. . .			+·27		
			22 14·27		
Corection for ch. semid . .			−04		
Corrected W interval . .			22 14·23		
Greenwich interval			13 57·06		
A			8 17·17=497·17		log . 2·696540.
☽'s hourly inc. of R A			2m 23·16s		Tab. 30 1·384095
Longitude W 50° 10′=12040s					log . 4·080635

Problem II.

To find the longitude on land from the sidereal time at which the moon's bright limb passes the meridian.

To the sidereal time of the transit apply the sidereal time which the moon's semidiameter, takes in passing the meridian, (given in the right column of the last of moon culminating stars in the Nautica Almanac,) adding it if the western, and subtracting it of the eastern limb is observed,—and the sum or the remainder will be the sidereal time when the moon's centre is on the meridian, or the moon's right ascension at that instant.

Find by the method given at p. 269 what mean Greenwich time corresponds to this right ascension of the moon, to which add the proportional part of 3m 55·91s, and the sidereal time at mean Greenwich noon, (given in the right hand column of p. ii. of each month in the Nautical

Almanac,) and the sum will be the sidereal time at Greenwich; the difference between which and the sidereal time of the transit of the moon's centre at the place of observation is the longitude of the place in time.

The proportional part of 3m 55·91s for Greenwich time, may be conveniently found thus:

To the log from Tab. 30 of the Greenwich mean time add 7845, and the sum will be the log, in the same table, of the required proportional part; hours and minutes in the table, being taken as minutes and seconds of the proportional part.

For example, if the Greenwich time found from the moon's right ascension be 2h 29m 6·18s, and the sidereal time at Greenwich mean noon be 18h 40m 29·33s, then we have

Greenwich mean time . .	2h	29m	6·18s	Tab. 30	9850
					7845
	h	m	s		
			24·49	Tab. 30	17695
Mean time at Greenwich	2	29	6·18		
Sid. time at Gr. mean noon	18	40	29·33		
Sidereal time at Greenwich	21	10	0·00		

ON WINDS.

The chief causes of winds are the expansion and contraction of the air from heat and cold; and, though in our climate nothing is more proverbial than the inconstancy of the winds, in some parts of the earth they appear to be governed by laws which operate with considerable regularity.

The most remarkable of these winds are the *Trade Winds*, which in a zone extending in general about 30° on each side of the equator, blow from the eastward nearly quite round the globe; inclining towards the north in north latitude, and towards the south in south latitude, and forming what are called the N E and S E trade winds. In the intermediate space the wind is variable, but it in general blows from the eastward. In this space, sudden squalls and heavy rains frequently occur.

When the sun has his greatest north declination, the S E trade wind extends several degrees N of the equator; and, in the opposite season, the N E trade wind extends in like manner to the south side of the equator; but in all seasons, these winds are found to be greatly modified by local circumstances, particularly near land. In the vast expanse of the Pacific Ocean they prevail almost uninterruptedly out at sea; but in the Atlantic, on the coast of Brazil, they blow from N E to E N E, from September till March, and from S S E to E E S

during the other half of the year. Near the African coast, the winds in general tend towards the coast; but, in the Gulf of Guinea, there is sometimes found a moderate breeze from the N E. Off this coast, about 7° N latitude, and 20° W longitude, there is a considerable space, where almost continual calms are found, attended with thunder and lightning; and the rains are so frequent and heavy, that the space has acquired the name of the *Rains*.

In the Indian Ocean, from about latitude 28° S to the equator, the S E trade wind blows pretty constantly; but in the Arabian Sea and the Bay of Bengal, there are certain periodical winds, called *monsoons*, which, from April till October, blow from S W, and from the opposite point from October till April. The S W monsoon is frequently attended with tempests and rain; but, during the prevalence of the N E monsoon, the weather is in general dry and pleasant. About the change from one monsoon to another, very violent storms of wind are usually met with.

Monsoons are found also in the Mozambique Channel, but the fair season there is during the S W, and the rainy season during the N E monsoon.

On the coasts of Sumatra and Java, and along the coast of China, monsoons also prevail; but they blow more nearly from the north and south than those in the Arabian Sea; and they are, besides, much less regular, and are frequently interrupted by violent hurricanes, called *tyfoons*. Off the western coast of New Holland, there are regular monsoons, which blow from N W from October till April, and from S E during the remainder of the year.

Beyond the limits to which the trade winds extend, the winds are so variable, that all attempts to deduce the laws by which they are governed, have hitherto been unsuccessful; westerly winds however are observed to be, on the whole, most frequent.

From what has been said, it will readily be perceived that a mariner, bound to the westward, will avail himself of the trade wind, when he can reach it without going too far out of his way; but this wind, so favourable in running towards the west, is directly adverse in sailing eastward, and it would therefore be a mere waste of time to attempt to sail to the eastward in the trade winds.

Indiamen, both outward and homeward bound, generally cross the equator between 18° and 23° west longitude, and thus avoid the coast of America, as well as the calms off the coast of Africa; and steering to the south-westward across the S E trade wind, till they reach the latitude where variable winds prevail, they then make towards the east, In sailing outwards in the Indian Ocean, they generally run down their longitude south of the parallel of the Cape of Good Hope, and then steer across the S E trade wind towards India

Ships bound from Europe for the West Indies, and the southern parts of North America, avail themselves of the trade wind, which they endeavour to reach as soon as possible; and, in returning, they steer towards the north, till they get without the limit of the trade wind, where they find the winds variable, and they then work their way towards the east.

Ships from the coast of Guinea sail from S to E S E, as the wind will permit, till they reach the island of St. Thomas; and with the wind which is generally found in that quarter, they run to the westward till they meet the S E trade wind.

Near the shore in tropical climates, there are daily land and sea breezes, the wind blowing from the sea during the heat of the day, and from the land during the night. In very warm weather these breezes are often observed to blow pretty regularly, even in temperate climates.

ON TIDES.

Tides are the daily rising and falling of the waters of the ocean, and they are produced by the attractions of the sun and moon, but chiefly by the attraction of the moon.

The attractive force of the moon, like that of every other body, varies in the inverse proportion of the square of its distance from the object which it attracts; and, consequently, the particles of the earth immediately under the moon are *more*, and those on the opposite side *less* attracted by her, than the intermediate parts are. And as the attraction of the moon, in the former case, acts in opposition to the gravity of the particles towards the earth's centre, their tendency towards the centre will be diminished; and, consequently, if they were at liberty to move freely among themselves, they would rise above the level of the place which they would otherwise occupy, and form a wave, which would follow the moon in her diurnal circuit round the earth. And although the moon's attractive force is in the same direction with the gravitating force of the particles on the opposite side of the earth, yet, as she exerts a greater force in the same direction, on the central parts, the relative gravitation of the central parts, and the particles on the opposite side towards each other will also be diminished; and, therefore, if at liberty to move freely, these particles will also rise above the general level, and form a wave or tide on the side opposite the moon.

The tide on the side next the moon, or that which happens when the moon is above the horizon, is called the *superior*, and the other the *inferior* tide.

Now it is only the particles of fluids that can be sensibly affected by such small variations in the gravitating forces; and it is only in the ocean, and large seas, that there is sufficient water to admit the effect even in fluids, to be distinctly observable.

The time of full tide, however, even if the earth were covered with water, would not be at the time at which the moon is on the meridian of any place; for the waters, having been once put in motion, would continue to rise for some time, even if the moon's action were to cease altogether; and they, of course, continue longer to rise when her force is only a little diminished.

The waters of the ocean are similarly affected by the attraction of the sun; but though his attractive force on the earth is immensely greater than the moon's, yet, from his great distance, the effect is more nearly equal upon every particle, and therefore the tides which he produces are, with respect to the moon's, comparatively small; and, in fact, they are only perceived in the modifications which they produce in the times and the heights of those which are primarily regulated by the moon.

In the interval between two successive transits of the moon, she produces two tides; and the sun, in every twenty-four hours, produces two tides also. The tides produced by the sun and moon coincide at the times of full and new moon; and the consequence is, that the tides at those times are higher. At the quarter of the moon, the effect of the solar is to diminish the lunar tide; and hence, at those times, we find the tides are below the average height. The tides at full and change are called *spring tides*, and those at the quarters *neap tides*; but the highest and lowest tides are generally about the *third tide* after the full and change, and the quarters.

As the action of the sun increases or diminishes the height of the lunar tide, so it also accelerates or retards the times at which high water happens.

When the moon is in the first and third quarters, the observed tide, or that compounded of the solar and lunar ones, is to the westward, and in the second and fourth quarters to the eastward of that raised by the moon alone; hence the action of the sun makes high water earlier in the former, and later in the latter case. This explanation will be received with a slight modification, arising from the consideration, that the solar and lunar tides are eastward of the places of the sun and moon, and consequently this acceleration and retardation, like the times of the highest spring and the lowest neap tides, will take place a little after the moon enters the quarters mentioned.

When the moon is at her least distance from the earth, the tides of course are greater than usual; and when the full or change of the moon happens about the beginning of January, when the sun also is

nearest the earth, the tides are the greatest of all. The nearer the moon passes the zenith of any place, the greater are the tides which she produces at that place.

In small seas which are much enclosed by land, such as the North Sea, the observed tides are supplied from those raised in the adjoining ocean; and the Baltic, the Mediterranean, and such other seas as communicate with the ocean by very small mouths, cannot receive a sufficient supply of water in a tide to produce a material elevation in their surfaces; in these seas, in consequence, the tides are found to be very trifling.

The times of high water at any individual place are greatly influenced by its local situation; but there is at every place a mean relation between the time of high water and that of the moon's passing the meridian, which relation is subject to periodical variations, depending on the distances and relative positions of the sun and moon. The time of high water too often is materially affected by the wind; but it may be found, with sufficient exactness for any practical purpose in navigation, by means of the following problems.

Problem I.

To find the moon's age on any day between the years 1800 *and* 1900.

The time of a mean lunation is nearly 29d 12h 44m, twelve of which make about 354d 9h, or about 10d 21h less than a solar year of 365d 6h. Hence the age of the moon, at the beginning of any year, will be 10d 21h greater than at the beginning of the preceding one, till it reach a complete lunation, when its excess above that quantity will be her age. And if the days elapsed from the beginning of the year were divided by 29d 12h 44m, the remainder would be the age of the moon, if the new moon happened at the commencement of the year; consequently if the moon's age at the beginning of the year were added to that remainder, the sum would be the moon's age on the proposed day.

These remainders, for the beginning of every month, increased by 5, the moon's age at the beginning of the year 1800, are given in the following table, both for leap years and common years; every year divisible by 4, without a remainder, being a leap year.

	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.
Common Years	5	6	5	6	7	8	9	10	12	12	14	14
Leap Years	5	7	6	7	8	9	10	11	13	13	15	15

To find the moon's age for any time between 1800 and 1900, subtract 1800 from the given year, multiply the remainder by 109, and divide the product by 295, and to the tenth part of the remainder add the day of the month and the number from the above table, and the sum, if it does not exceed 30, is the moon's age; if it exceed 30, the excess above 30 is her age.

Problem II.

To find the time at which the moon passes the meridian on a given day.

If the new moon happen at noon, the sun and moon will be on the meridian together; and as the moon, at a mean rate, is about 49 minutes later in coming to the meridian every day, if we multiply 49 by her age in days, and divide the product by 60, the quotient will be the hours, and the remainder the minutes past noon, when she passes the meridian on the given day, on the supposition that her motion is uniform, and that she changes at noon. But as her motion is not uniform, and she seldom changes precisely at noon, this method of finding the time of her transit must be considered as only an approximate one. The method of finding it correctly, with the aid of the Nautical Almanac, has been given at Problem 5, p. 216, and those who possess the Nautical Almanac will of course employ that method.

Example.

It is required to find, by the two preceding problems, the moon's age nearly, and the approximate time of her passing the meridian on September 10, 1823?

$109 \times 23 = 2507$, which, divided by 295, gives 8 for the quotient, and an integral remainder of 147.

Tenth of the remainder .	14
No. for September, 1823.	12
Day of the month	10
	36
Deduct	30
Moon's age	6, and $\frac{6 \times 49}{60} = 4\text{h}\ 54\text{m}$, the time

of her passing the meridian.

Examples for Exercise.

It is required from the two preceding problems, without the aid of the Nautical Almanac, to determine approximately the moon's age, and the time of her passing the meridian on each of the following days?

Date.	Moon's Age.	Hour, &c., of Transit.
	days	h m
November 2, 1824	12	9 48
January 15, 1830	22	17 58
July 22, 1851	25	20 25
December 21, 1872	13	10 37
September 23, 1823	19	15 31

Problem III.

To find the time of high water on a given day at any place where the time of high water at full and change is known.

Let the time of the moon's passing the meridian of the given place be found by Prob. 5, p. 216, and to this time apply the correction from the following table, corresponding to her meridian passage and semidiameter, and to the result add the time of high water at full and change at the given place, as given in Table 35, or 36, and the sum will be the time of high water on the afternoon of the given day. If this sum exceed 12h 24m, or 24h 49m, subtract those times from it, and the remainder will be nearly the time of high water on the afternoon of the given day.

If the computer have not a Nautical Almanac, he may find the approximate time of the moon's passing the meridian by the two preceding problems, and applying to it the correction from the middle column in the following table, add the result to the time of high water, at full and change, from Table 35, or 36, and the sum will give the time of high water, generally within less than an hour of the truth.

Since 1834, the time of the moon's meridian passage is given in mean time; to find the app. time to enter the following table apply to the mean time, the minutes in the equation of time with the sign given in page ii of the Nautical Almanac.

Corrections to be applied to the time of the moon's meridian passage in finding the time of high water.

☽'s Mer. Pass. App. Time.	☽'s Semidiameter.			☽'s Mer. Pass. App. Time.	☽'s Mer. Pass. App. Time.	☽'s Semidiameter.			☽'s Mer. Pass. App. Time.
	16′ 30″	15′ 30″	14′ 30″			16′ 30″	15′ 30″	14′ 30″	
h m	h m	h m	h m	h m	h m	h m	h m	h m	h m
0 0	− 0 4	0 0	+ 0 5	12 0	6 0	− 0 55	− 1 2	− 1 12	18 0
0 30	− 0 10	− 0 8	− 0 5	12 30	6 30	− 0 46	− 0 51	− 0 58	18 30
1 0	− 0 17	− 0 16	− 0 15	13 0	7 0	− 0 32	− 0 34	− 0 37	19 0
1 30	− 0 24	− 0 25	− 0 25	13 30	7 30	− 0 17	− 0 16	− 0 14	19 30
2 0	− 0 31	− 0 34	− 0 36	14 0	8 0	− 0 1	+ 0 3	+ 0 9	20 0
2 30	− 0 38	− 0 41	− 0 46	14 30	8 30	+ 0 8	+ 0 15	+ 0 24	20 30
3 0	− 0 44	− 0 49	− 0 55	15 0	9 0	+ 0 14	+ 0 21	+ 0 32	21 0
3 30	− 0 50	− 0 56	− 1 4	15 30	9 30	+ 0 16	+ 0 24	+ 0 36	21 30
4 0	− 0 55	− 1 2	− 1 12	16 0	10 0	+ 0 15	+ 0 23	+ 0 34	22 0
4 30	− 0 58	− 1 6	− 1 16	16 30	10 30	+ 0 12	+ 0 19	+ 0 29	22 30
5 0	− 1 0	− 1 8	− 1 19	17 0	11 0	+ 0 7	+ 0 14	+ 0 23	23 0
5 30	− 0 59	− 1 7	− 1 18	17 30	11 30	+ 0 2	+ 0 7	+ 0 15	23 30
6 0	− 0 56	− 1 2	− 1 12	18 0	12 0	− 0 4	0 0	+ 0 5	24 0

Example.

Required the time of high water September 10, 1823, at Quebec?

☽'s meridian pass., Nautical Almanac,
(see Table 32) ..... 4h 32m + 51m, semid 15′
Correction for longitude, Table 17 ..... + 10

4 42
Correction from the above Table..... − 1 12

3 30
High water at full and change, Tab. 35, 7 30

Answer 11 0

The same computed by the other method.

In the example to Problem 2, the time of the moon's
passing the meridian is computed to be 4h 54m
Cor. from the middle column of the above Table ..... − 1 7

3 47
Time from Table 33 ..... 7 30

Answer 11 17

Examples for Exercise.

The time of high water is required in the afternoon at each of the places mentioned in the following examples, on the respective days mentioned, the requisite data from the Nautical Almanac being given in Table 32?

Time.	Place.	Time of High Water.	
		h m	
September 20, 1823	Amazon R. Ent.	6 3	P.M.
September 23, 1823	Lisbon	3 56	
September 14, 1823	Rio Janeiro	10 12	
September 7, 1823	Funchal	1 33	
September 25, 1823	Cape Town	5 44	

The time of high water in the afternoon is required in each of the following examples, computing the moon's age, and the time of her meridian passage, by the two preceding problems?

Time.	Place.	Moon's Age.	Moon's Mer. Pass.	Time of High Water.	
		days.	h m	h m	
July 16, 1829	Newcastle	16	13 4	4 24	P.M.
Nov. 4, 1848	Liverpool	11	8 59	7 56	
Feb. 3, 1882	Stromness	17	13 53	9 56	
April 28, 1870	Cape Finisterre	26	21 14	12 12	
June 10, 1896	Easter Island	2	1 38	3 11	

Problem IV.

From the observed time at high water at any place on a given day, to find the time of high water at full and change.

To the time at which the moon passes the meridian of the given place, found by Prob. 5, p. 216, or Prob. 2, p. 325, apply the correction from the preceding table, and the result, subtracted from the observed time of high water, will leave the time of high water on the afternoon of the days of full and change.

If the time to be subtracted exceed the observed time of high water, let 12h 24m, or 24h 49m, (whichever is necessary to make it greater,) be added to the observed time before the subtraction is made.

Example.

It was observed to be high water at Quebec, on September 10, 1823, at 11h 0m, required the time of high water at full and change?

In the last problem, the time of the moon's passing the meridian on the given day, corrected by the equation from the table, was found to be 3h 30m, which, subtracted from 11h 0m, leaves 7h 30m for the required time of high water at full and change.

Examples for Exercise.

The time of high water, at full and change, is required in each of the following examples, from the time at which it was observed on the given day?

Place.	Day.	Observed Time of High Water.	Time of High Water at Full and Change.
		h m	h m
Amazon R. Ent.	September 20, 1823	6 3 P.M.	6 0
Lisbon	September 23, 1823	3 56	2 15
Rio Janeiro	September 14, 1823	10 12	2 5
Funchal	September 7, 1823	1 33	0 4
Cape Town	September 25, 1823	5 44	2 30

An extensive series of observations of the times and heights of the tides has been undertaken by the officers of the coast guard service, to serve as a foundation of investigations for predicting them in a more satisfactory manner than has hitherto been done.

Problem V.

From the mean height of the spring and neap tides at any place, to find the height of any other tide at that place.

With the moon's semidiameter at the top, and the apparent time of her meridian passage in the side column of the following table, take out the numbers below A and B; and multiply the number below A by the mean height of the spring tide, and that below B by the *mean* height of the neap tide, and the sum of the products will be nearly the height of the required tide, independent of winds, freshes, &c., of which it is impossible to estimate the effects. This table is due to Bernoulli.

Apparent Time of Moon's Mer. Pass.		Moon's Semidiameter.					
		16′ 30″		15′ 30″		14′ 30″	
		A	B	A	B	A	B
h m	h m						
0 0	24 0	0·99	0·15	0·88	0·12	0·79	0·08
0 40	23 20	1·10	0·04	0·97	0·03	0·87	0·02
1 20	22 40	1·14	0·00	1·00	0·00	0·90	0·00
2 0	22 0	1·10	0·04	0·97	0·03	0·87	0·02
2 40	21 20	0·99	0·15	0·88	0·12	0·79	0·08
3 20	20 40	0·85	0·32	0·75	0·25	0·68	0·18
4 0	20 0	0·67	0·53	0·59	0·41	0·53	0·29
4 40	19 20	0·46	0·75	0·41	0·59	0·37	0·41
5 20	18 40	0·28	0·96	0·25	0·75	0·23	0·53
6 0	18 0	0·13	1·13	0·12	0·88	0·11	0·62
6 40	17 20	0·03	1·24	0·03	0·97	0·03	0·68
7 20	16 40	0·00	1·28	0·00	1·00	0·00	0·70
8 0	16 0	0·03	1·24	0·03	0·97	0·03	0·68
8 40	15 20	0·13	1·13	0·12	0·88	0·11	0·62
9 20	14 40	0·28	0·96	0·25	0·75	0·23	0·53
10 0	14 0	0·46	0·75	0·41	0·59	0·37	0·41
10 40	13 20	0·67	0·53	0·59	0·41	0·53	0·29
11 20	12 40	0·85	0·32	0·75	0·25	0·68	0·18
12 0	12 0	0·99	0·15	0·88	0·12	0·79	0·08

Example.

If the height of the spring tide at a certain place be 18 feet, and that of the neap tide 14 feet, required the height of the tide when the time of the moon's meridian passage is 8h 40m, and her semidiameter 15′ 30″?

Here we have A = ·12 and B = ·88

And ·12 × 18 = 2·16

·88 × 14 = 12·32

Answer ... 14·48

Examples for Exercise.

In each of the following examples the height of the tide is required?

No.	Date.	Height of Spring Tide.	Height of Neap Tide.	Answer.
		feet.	feet.	feet.
1	September 11, 1823	20	12	15·5
2	September 19, 1823	15	9	14·9
3	September 29, 1823	25	13	22·2
4	September 2, 1823	12	8	13·7

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Difference of Latitude and Departure for $\frac{1}{4}$ Point.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	01.0	00.0	61	60.9	03.0	121	120.9	05.9	181	180.8	08.9	241	240.7	11.8
2	02.0	00.1	62	61.9	03.0	122	121.9	06.0	182	181.8	08.9	242	241.7	11.9
3	03.0	00.1	63	62.9	03.1	123	122.9	06.0	183	182.8	09.0	243	242.7	11.9
4	04.0	00.2	64	63.9	03.1	124	123.9	06.1	184	183.8	09.0	244	243.7	12.0
5	05.0	00.2	65	64.9	03.2	125	124.9	06.1	185	184.8	09.1	245	244.7	12.0
6	06.0	00.3	66	65.9	03.2	126	125.8	06.2	186	185.8	09.1	246	245.7	12.1
7	07.0	00.3	67	66.9	03.3	127	126.8	06.2	187	186.8	09.2	247	246.7	12.1
8	08.0	00.4	68	67.9	03.3	128	127.8	06.3	188	187.8	09.2	248	247.7	12.2
9	09.0	00.4	69	68.9	03.4	129	128.8	06.3	189	188.8	09.3	249	248.7	12.2
10	10.0	00.5	70	69.9	03.4	130	129.8	06.4	190	189.8	09.3	250	249.7	12.3
11	11.0	00.5	71	70.9	03.5	131	130.8	06.4	191	190.8	09.4	251	250.7	12.3
12	12.0	00.6	72	71.9	03.5	132	131.8	06.5	192	191.8	09.4	252	251.7	12.4
13	13.0	00.6	73	72.9	03.6	133	132.8	06.5	193	192.8	09.5	253	252.7	12.4
14	14.0	00.7	74	73.9	03.6	134	133.8	06.6	194	193.8	09.5	254	253.7	12.5
15	15.0	00.7	75	74.9	03.7	135	134.8	06.6	195	194.8	09.6	255	254.7	12.5
16	16.0	00.8	76	75.9	03.7	136	135.8	06.7	196	195.8	09.6	256	255.7	12.6
17	17.0	00.8	77	76.9	03.8	137	136.8	06.7	197	196.8	09.7	257	256.7	12.6
18	18.0	00.9	78	77.9	03.8	138	137.8	06.8	198	197.8	09.7	258	257.7	12.7
19	19.0	00.9	79	78.9	03.9	139	138.8	06.8	199	198.8	09.8	259	258.7	12.7
20	20.0	01.0	80	79.9	03.9	140	139.8	06.9	200	199.8	09.8	260	259.7	12.8
21	21.0	01.0	81	80.9	04.0	141	140.8	06.9	201	200.8	09.9	261	260.7	12.8
22	22.0	01.1	82	81.9	04.0	142	141.8	07.0	202	201.8	09.9	262	261.7	12.9
23	23.0	01.1	83	82.9	04.1	143	142.8	07.0	203	202.8	10.0	263	262.7	12.9
24	24.0	01.2	84	83.9	04.1	144	143.8	07.1	204	203.8	10.0	264	263.7	13.0
25	25.0	01.2	85	84.9	04.2	145	144.8	07.1	205	204.8	10.1	265	264.7	13.0
26	26.0	01.3	86	85.9	04.2	146	145.8	07.2	206	205.8	10.1	266	265.7	13.1
27	27.0	01.3	87	86.9	04.3	147	146.8	07.2	207	206.8	10.2	267	266.7	13.1
28	28.0	01.4	88	87.9	04.3	148	147.8	07.3	208	207.8	10.2	268	267.7	13.2
29	29.0	01.4	89	88.9	04.4	149	148.8	07.3	209	208.8	10.3	269	268.7	13.2
30	30.0	01.5	90	89.9	04.4	150	149.8	07.4	210	209.8	10.3	270	269.7	13.3
31	31.0	01.5	91	90.9	04.5	151	150.8	07.4	211	210.7	10.4	271	270.7	13.3
32	32.0	01.6	92	91.9	04.5	152	151.8	07.5	212	211.7	10.4	272	271.7	13.3
33	33.0	01.6	93	92.9	04.6	153	152.8	07.5	213	212.7	10.5	273	272.7	13.4
34	34.0	01.7	94	93.9	04.6	154	153.8	07.6	214	213.7	10.5	274	273.7	13.4
35	35.0	01.7	95	94.9	04.7	155	154.8	07.6	215	214.7	10.6	275	274.7	13.5
36	36.0	01.8	96	95.9	04.7	156	155.8	07.7	216	215.7	10.6	276	275.7	13.5
37	37.0	01.8	97	96.9	04.8	157	156.8	07.7	217	216.7	10.7	277	276.7	13.6
38	38.0	01.9	98	97.9	04.8	158	157.8	07.8	218	217.7	10.7	278	277.7	13.6
39	39.0	01.9	99	98.9	04.9	159	158.8	07.8	219	218.7	10.8	279	278.7	13.7
40	40.0	02.0	100	99.9	04.9	160	159.8	07.9	220	219.7	10.8	280	279.7	13.7
41	41.0	02.0	101	100.9	05.0	161	160.8	07.9	221	220.7	10.8	281	280.7	13.8
42	41.9	02.1	102	101.9	05.0	162	161.8	08.0	222	221.7	10.9	282	281.7	13.8
43	42.9	02.1	103	102.9	05.1	163	162.8	08.0	223	222.7	10.9	283	282.7	13.9
44	43.9	02.2	104	103.9	05.1	164	163.8	08.1	224	223.7	11.0	284	283.7	13.9
45	44.9	02.2	105	104.9	05.2	165	164.8	08.1	225	224.7	11.0	285	284.7	14.0
46	45.9	02.3	106	105.9	05.2	166	165.8	08.2	226	225.7	11.1	286	285.7	14.0
47	46.9	02.3	107	106.9	05.3	167	166.8	08.2	227	226.7	11.1	287	286.7	14.1
48	47.9	02.4	108	107.9	05.3	168	167.8	08.2	228	227.7	11.2	288	287.7	14.1
49	48.9	02.4	109	108.9	05.4	169	168.8	08.3	229	228.7	11.2	289	288.7	14.2
50	49.9	02.5	110	109.9	05.4	170	169.8	08.3	230	229.7	11.3	290	289.7	14.2
51	50.9	02.5	111	110.9	05.5	171	170.8	08.4	231	230.7	11.3	291	290.7	14.3
52	51.9	02.6	112	111.9	05.5	172	171.8	08.4	232	231.7	11.4	292	291.7	14.3
53	52.9	02.6	113	112.9	05.5	173	172.8	08.5	233	232.7	11.4	293	292.7	14.4
54	53.9	02.7	114	113.9	05.6	174	173.8	08.5	234	233.7	11.5	294	293.6	14.4
55	54.9	02.7	115	114.9	05.6	175	174.8	08.6	235	234.7	11.5	295	294.6	14.5
56	55.9	02.8	116	115.9	05.7	176	175.8	08.6	236	235.7	11.6	296	295.6	14.5
57	56.9	02.8	117	116.9	05.7	177	176.8	08.7	237	236.7	11.6	297	296.6	14.6
58	57.9	02.9	118	117.9	05.8	178	177.8	08.7	238	237.7	11.7	298	297.6	14.6
59	58.9	02.9	119	118.9	05.8	179	178.8	08.8	239	238.7	11.7	299	298.6	14.7
60	59.9	02.9	120	119.9	05.9	180	179.8	08.8	240	239.7	11.8	300	299.6	14.7
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Difference of Latitude and Departure for $\frac{1}{2}$ Point.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	01.0	00.1	61	60.7	06.0	121	120.4	11.9	181	180.1	17.7	241	239.8	23.6
2	02.0	00.2	62	61.7	06.1	122	121.4	12.0	182	181.1	17.8	242	240.8	23.7
3	03.0	00.3	63	62.7	06.2	123	122.4	12.1	183	182.1	17.9	243	241.8	23.8
4	04.0	00.4	64	63.7	06.3	124	123.4	12.2	184	183.1	18.0	244	242.8	23.9
5	05.0	00.5	65	64.7	06.4	125	124.4	12.3	185	184.1	18.1	245	243.8	24.0
6	06.0	00.6	66	65.7	06.5	126	125.4	12.3	186	185.1	18.2	246	244.8	24.1
7	07.0	00.7	67	66.7	06.6	127	126.4	12.4	187	186.1	18.3	247	245.8	24.2
8	08.0	00.8	68	67.7	06.7	128	127.4	12.5	188	187.1	18.4	248	246.8	24.3
9	09.0	00.9	69	68.7	06.8	129	128.4	12.6	189	188.1	18.5	249	247.8	24.4
10	10.0	01.0	70	69.7	06.9	130	129.4	12.7	190	189.1	18.6	250	248.8	24.5
11	10.9	01.1	71	70.7	07.0	131	130.4	12.8	191	190.1	18.7	251	249.8	24.6
12	11.9	01.2	72	71.7	07.1	132	131.4	12.9	192	191.1	18.8	252	250.8	24.7
13	12.9	01.3	73	72.7	07.2	133	132.4	13.0	193	192.1	18.9	253	251.8	24.8
14	13.9	01.4	74	73.6	07.3	134	133.4	13.1	194	193.1	19.0	254	252.8	24.9
15	14.9	01.5	75	74.6	07.4	135	134.3	13.2	195	194.1	19.1	255	253.8	25.0
16	15.9	01.6	76	75.6	07.4	136	135.3	13.3	196	195.1	19.2	256	254.8	25.1
17	16.9	01.7	77	76.6	07.5	137	136.3	13.4	197	196.1	19.3	257	255.8	25.2
18	17.9	01.8	78	77.6	07.6	138	137.3	13.5	198	197.0	19.4	258	256.8	25.3
19	18.9	01.9	79	78.6	07.7	139	138.3	13.6	199	198.0	19.5	259	257.8	25.4
20	19.9	02.0	80	79.6	07.8	140	139.3	13.7	200	199.0	19.6	260	258.7	25.5
21	20.9	02.1	81	80.6	07.9	141	140.3	13.8	201	200.0	19.7	261	259.7	25.6
22	21.9	02.2	82	81.6	08.0	142	141.3	13.9	202	201.0	19.8	262	260.7	25.7
23	22.9	02.3	83	82.6	08.1	143	142.3	14.0	203	202.0	19.9	263	261.7	25.8
24	23.9	02.4	84	83.6	08.2	144	143.3	14.1	204	203.0	20.0	264	262.7	25.9
25	24.9	02.4	85	84.6	08.3	145	144.3	14.2	205	204.0	20.1	265	263.7	26.0
26	25.9	02.5	86	85.6	08.4	146	145.3	14.3	206	205.0	20.2	266	264.7	26.1
27	26.9	02.6	87	86.6	08.5	147	146.3	14.4	207	206.0	20.3	267	265.7	26.2
28	27.9	02.7	88	87.6	08.6	148	147.3	14.5	208	207.0	20.4	268	266.7	26.3
29	28.9	02.8	89	88.6	08.7	149	148.3	14.6	209	208.0	20.5	269	267.7	26.4
30	29.9	02.9	90	89.6	08.8	150	149.3	14.7	210	209.0	20.6	270	268.7	26.5
31	30.9	03.0	91	90.6	08.9	151	150.3	14.8	211	210.0	20.7	271	269.7	26.6
32	31.8	03.1	92	91.6	09.0	152	151.3	14.9	212	211.0	20.8	272	270.7	26.7
33	32.8	03.2	93	92.6	09.1	153	152.3	15.0	213	212.0	20.9	273	271.7	26.8
34	33.8	03.3	94	93.6	09.2	154	153.3	15.1	214	213.0	21.0	274	272.7	26.9
35	34.8	03.4	95	94.5	09.3	155	154.3	15.2	215	214.0	21.1	275	273.7	27.0
36	35.8	03.5	96	95.5	09.4	156	155.2	15.3	216	215.0	21.2	276	274.7	27.1
37	36.8	03.6	97	96.5	09.5	157	156.2	15.4	217	216.0	21.3	277	275.7	27.2
38	37.8	03.7	98	97.5	09.6	158	157.2	15.5	218	216.9	21.4	278	276.7	27.3
39	38.8	03.8	99	98.5	09.7	159	158.2	15.6	219	217.9	21.5	279	277.7	27.3
40	39.8	03.9	100	99.5	09.8	160	159.2	15.7	220	218.9	21.6	280	278.7	27.4
41	40.8	04.0	101	100.5	09.9	161	160.2	15.8	221	219.9	21.7	281	279.6	27.5
42	41.8	04.1	102	101.5	10.0	162	161.2	15.9	222	220.9	21.8	282	280.6	27.6
43	42.8	04.2	103	102.5	10.1	163	162.2	16.0	223	221.9	21.9	283	281.6	27.7
44	43.8	04.3	104	103.5	10.2	164	163.2	16.1	224	222.9	22.0	284	282.6	27.8
45	44.8	04.4	105	104.5	10.3	165	164.2	16.2	225	223.9	22.1	285	283.6	27.9
46	45.8	04.5	106	105.5	10.4	166	165.2	16.3	226	224.9	22.2	286	284.6	28.0
47	46.8	04.6	107	106.5	10.5	167	166.2	16.4	227	225.9	22.2	287	285.6	28.1
48	47.8	04.7	108	107.5	10.6	168	167.2	16.5	228	226.9	22.3	288	286.6	28.2
49	48.8	04.8	109	108.5	10.7	169	168.2	16.6	229	227.9	22.4	289	287.6	28.3
50	49.8	04.9	110	109.5	10.8	170	169.2	16.7	230	228.9	22.5	290	288.6	28.4
51	50.8	05.0	111	110.5	10.9	171	170.2	16.8	231	229.9	22.6	291	289.6	28.5
52	51.7	05.1	112	111.5	11.0	172	171.2	16.9	232	230.9	22.7	292	290.6	28.6
53	52.7	05.2	113	112.5	11.1	173	172.2	17.0	233	231.9	22.8	293	291.6	28.7
54	53.7	05.3	114	113.5	11.2	174	173.2	17.1	234	232.9	22.9	294	292.6	28.8
55	54.7	05.4	115	114.5	11.3	175	174.2	17.2	235	233.9	23.0	295	293.6	28.9
56	55.7	05.5	116	115.4	11.4	176	175.2	17.3	236	234.9	23.1	296	294.6	29.0
57	56.7	05.6	117	116.4	11.5	177	176.1	17.4	237	235.9	23.2	297	295.6	29.1
58	57.7	05.7	118	117.4	11.6	178	177.1	17.4	238	236.9	23.3	298	296.6	29.2
59	58.7	05.8	119	118.4	11.7	179	178.1	17.5	239	237.8	23.4	299	297.6	29.3
60	59.7	05.9	120	119.4	11.8	180	179.1	17.6	240	238.8	23.5	300	298.6	29.4
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

TABLE I.

Difference of Latitude and Departure for $\frac{3}{4}$ Point.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	01.0	00.1	61	60.3	08.9	121	119.7	17.7	181	179.0	26.6	241	238.4	35.4
2	02.0	00.3	62	61.3	09.1	122	120.7	17.9	182	180.0	26.7	242	239.4	35.5
3	03.0	00.4	63	62.3	09.2	123	121.7	18.0	183	181.0	26.8	243	240.4	35.7
4	04.0	00.6	64	63.3	09.4	124	122.7	18.2	184	182.0	27.0	244	241.4	35.8
5	04.9	00.7	65	64.3	09.5	125	123.6	18.3	185	183.0	27.1	245	242.3	35.9
6	05.9	00.9	66	65.3	09.7	126	124.6	18.5	186	184.0	27.3	246	243.3	36.1
7	06.9	01.0	67	66.3	09.8	127	125.6	18.6	187	185.0	27.4	247	244.3	36.2
8	07.9	01.2	68	67.3	10.0	128	126.6	18.8	188	186.0	27.6	248	245.3	36.4
9	08.9	01.3	69	68.2	10.1	129	127.6	18.9	189	186.9	27.7	249	246.3	36.5
10	09.9	01.5	70	69.2	10.3	130	128.6	19.1	190	187.9	27.9	250	247.3	36.7
11	10.9	01.6	71	70.2	10.4	131	129.6	19.2	191	188.9	28.0	251	248.3	36.8
12	11.9	01.8	72	71.2	10.6	132	130.6	19.4	192	189.9	28.2	252	249.3	37.0
13	12.9	01.9	73	72.2	10.7	133	131.6	19.5	193	190.9	28.3	253	250.3	37.1
14	13.8	02.1	74	73.2	10.9	134	132.5	19.7	194	191.9	28.5	254	251.2	37.3
15	14.8	02.2	75	74.2	11.0	135	133.5	19.8	195	192.9	28.6	255	252.2	37.4
16	15.8	02.3	76	75.2	11.1	136	134.5	20.0	196	193.9	28.8	256	253.2	37.6
17	16.8	02.5	77	76.2	11.3	137	135.5	20.1	197	194.9	28.9	257	254.2	37.7
18	17.8	02.6	78	77.2	11.4	138	136.5	20.2	198	195.9	29.0	258	255.2	37.9
19	18.8	02.8	79	78.1	11.6	139	137.5	20.4	199	196.8	29.2	259	256.2	38.0
20	19.8	02.9	80	79.1	11.7	140	138.5	20.5	200	197.8	29.3	260	257.2	38.1
21	20.8	03.1	81	80.1	11.9	141	139.5	20.7	201	198.8	29.5	261	258.2	38.3
22	21.8	03.2	82	81.1	12.0	142	140.5	20.8	202	199.8	29.6	262	259.2	38.4
23	22.7	03.4	83	82.1	12.2	143	141.4	21.0	203	200.8	29.8	263	260.1	38.6
24	23.7	03.5	84	83.1	12.3	144	142.4	21.1	204	201.8	29.9	264	261.1	38.7
25	24.7	03.7	85	84.1	12.5	145	143.4	21.3	205	202.8	30.1	265	262.1	38.9
26	25.7	03.8	86	85.1	12.6	146	144.4	21.4	206	203.8	30.2	266	263.1	39.0
27	26.7	04.0	87	86.1	12.8	147	145.4	21.6	207	204.8	30.4	267	264.1	39.2
28	27.7	04.1	88	87.0	12.9	148	146.4	21.7	208	205.7	30.5	268	265.1	39.3
29	28.7	04.3	89	88.0	13.1	149	147.4	21.9	209	206.7	30.7	269	266.1	39.5
30	29.7	04.4	90	89.0	13.2	150	148.4	22.0	210	207.7	30.8	270	267.1	39.6
31	30.7	04.5	91	90.0	13.3	151	149.4	22.2	211	208.7	30.9	271	268.1	39.8
32	31.7	04.7	92	91.0	13.5	152	150.3	22.3	212	209.7	31.1	272	269.0	39.9
33	32.6	04.8	93	92.0	13.6	153	151.3	22.4	213	210.7	31.2	273	270.0	40.1
34	33.6	05.0	94	93.0	13.8	154	152.3	22.6	214	211.7	31.4	274	271.0	40.2
35	34.6	05.1	95	94.0	13.9	155	153.3	22.7	215	212.7	31.5	275	272.0	40.3
36	35.6	05.3	96	95.0	14.1	156	154.3	22.9	216	213.7	31.7	276	273.0	40.5
37	36.6	05.4	97	95.9	14.2	157	155.3	23.0	217	214.6	31.8	277	274.0	40.6
38	37.6	05.6	98	96.9	14.4	158	156.3	23.2	218	215.6	32.0	278	275.0	40.8
39	38.6	05.7	99	97.9	14.5	159	157.3	23.3	219	216.6	32.1	279	276.0	40.9
40	39.6	05.9	100	98.9	14.7	160	158.3	23.5	220	217.6	32.3	280	277.0	41.1
41	40.6	06.0	101	99.9	14.8	161	159.3	23.6	221	218.6	32.4	281	278.0	41.2
42	41.5	06.2	102	100.9	15.0	162	160.2	23.8	222	219.6	32.6	282	278.9	41.4
43	42.5	06.3	103	101.9	15.1	163	161.2	23.9	223	220.6	32.7	283	279.9	41.5
44	43.5	06.5	104	102.9	15.3	164	162.2	24.1	224	221.6	32.9	284	280.9	41.7
45	44.5	06.6	105	103.9	15.4	165	163.2	24.2	225	222.6	33.0	285	281.9	41.8
46	45.5	06.7	106	104.8	15.5	166	164.2	24.4	226	223.5	33.2	286	282.9	42.0
47	46.5	06.9	107	105.8	15.7	167	165.2	24.5	227	224.5	33.3	287	283.9	42.1
48	47.5	07.0	108	106.8	15.8	168	166.2	24.6	228	225.5	33.4	288	284.9	42.3
49	48.5	07.2	109	107.8	16.0	169	167.2	24.8	229	226.5	33.6	289	285.9	42.4
50	49.5	07.3	110	108.8	16.1	170	168.2	24.9	230	227.5	33.7	290	286.9	42.5
51	50.4	07.5	111	109.8	16.3	171	169.1	25.1	231	228.5	33.9	291	287.8	42.7
52	51.4	07.6	112	110.8	16.4	172	170.1	25.2	232	229.5	34.0	292	288.8	42.8
53	52.4	07.8	113	111.8	16.6	173	171.1	25.4	233	230.5	34.2	293	289.8	43.0
54	53.4	07.9	114	112.8	16.7	174	172.1	25.5	234	231.5	34.3	294	290.8	43.1
55	54.4	08.1	115	113.7	16.9	175	173.1	25.7	235	232.4	34.5	295	291.8	43.3
56	55.4	08.2	116	114.7	17.0	176	174.1	26.8	236	233.4	34.6	296	292.8	43.4
57	56.4	08.4	117	115.7	17.2	177	175.1	26.0	237	234.4	34.8	297	293.8	43.6
58	57.4	08.5	118	116.7	17.3	178	176.1	26.1	238	235.4	34.9	298	294.8	43.7
59	58.4	08.7	119	117.7	17.5	179	177.1	26.3	239	236.4	35.1	299	295.8	43.9
60	59.3	08.8	120	118.7	17.6	180	178.0	26.4	240	237.4	35.2	300	296.8	44.0
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep	Lat.

Difference of Latitude and Departure for 1 Point.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	01.0	00.2	61	59.8	11.9	121	118.7	23.6	181	177.5	35.3	241	236.4	47.0
2	02.0	00.4	62	60.8	12.1	122	119.7	23.8	182	178.5	35.5	242	237.3	47.2
3	02.9	00.6	63	61.8	12.3	123	120.6	24.0	183	179.5	35.7	243	238.3	47.4
4	03.9	00.8	64	62.8	12.5	124	121.6	24.2	184	180.5	35.9	244	239.3	47.6
5	04.9	01.0	65	63.7	12.7	125	122.6	24.4	185	181.4	36.1	245	240.3	47.8
6	05.9	01.2	66	64.7	12.9	126	123.6	24.6	186	182.4	36.3	246	241.3	48.0
7	06.9	01.4	67	65.7	13.1	127	124.6	24.8	187	183.4	36.5	247	242.3	48.2
8	07.8	01.6	68	66.7	13.3	128	125.5	25.0	188	184.4	36.7	248	243.2	48.4
9	08.8	01.8	69	67.7	13.5	129	126.5	25.2	189	185.4	36.9	249	244.2	48.6
10	09.8	02.0	70	68.7	13.7	130	127.5	25.4	190	186.3	37.1	250	245.2	48.8
11	10.8	02.1	71	69.6	13.9	131	128.5	25.6	191	187.3	37.3	251	246.2	49.0
12	11.8	02.3	72	70.6	14.0	132	129.5	25.8	192	188.3	37.5	252	247.2	49.2
13	12.7	02.5	73	71.6	14.2	133	130.4	26.0	193	189.3	37.7	253	248.1	49.4
14	13.7	02.7	74	72.6	14.4	134	131.4	26.1	194	190.3	37.8	254	249.1	49.6
15	14.7	02.9	75	73.6	14.6	135	132.4	26.3	195	191.2	38.0	255	250.1	49.7
16	15.7	03.1	76	74.5	14.8	136	133.4	26.5	196	192.2	38.2	256	251.1	49.9
17	16.7	03.3	77	75.5	15.0	137	134.4	26.7	197	193.2	38.4	257	252.1	50.1
18	17.7	03.5	78	76.5	15.2	138	135.3	26.9	198	194.2	38.6	258	253.0	50.3
19	18.6	03.7	79	77.5	15.4	139	136.3	27.1	199	195.2	38.8	259	254.0	50.5
20	19.6	03.9	80	78.5	15.6	140	137.3	27.3	200	196.2	39.0	260	255.0	50.7
21	20.6	04.1	81	79.4	15.8	141	138.3	27.5	201	197.1	39.2	261	256.0	50.9
22	21.6	04.3	82	80.4	16.0	142	139.3	27.7	202	198.1	39.4	262	257.0	51.1
23	22.6	04.5	83	81.4	16.2	143	140.2	27.9	203	199.1	39.6	263	257.9	51.3
24	23.5	04.7	84	82.4	16.4	144	141.2	28.1	204	200.1	39.8	264	258.9	51.5
25	24.5	04.9	85	83.4	16.6	145	142.2	28.3	205	201.1	40.0	265	259.9	51.7
26	25.5	05.1	86	84.3	16.8	146	143.2	28.5	206	202.0	40.2	266	260.9	51.9
27	26.5	05.3	87	85.3	17.0	147	144.2	28.7	207	203.0	40.4	267	261.9	52.1
28	27.5	05.5	88	86.3	17.2	148	145.2	28.9	208	204.0	40.6	268	262.8	52.3
29	28.4	05.7	89	87.3	17.4	149	146.1	29.1	209	205.0	40.8	269	263.8	52.5
30	29.4	05.9	90	88.3	17.6	150	147.1	29.3	210	206.0	41.0	270	264.8	52.7
31	30.4	06.0	91	89.2	17.8	151	148.1	29.5	211	206.9	41.2	271	265.8	52.9
32	31.4	06.2	92	90.2	18.0	152	149.1	29.7	212	207.9	41.4	272	266.8	53.1
33	32.4	06.4	93	91.2	18.1	153	150.1	29.9	213	208.9	41.6	273	267.8	53.3
34	33.3	06.6	94	92.2	18.3	154	151.0	30.0	214	209.9	41.7	274	268.7	53.5
35	34.3	06.8	95	93.2	18.5	155	152.0	30.2	215	210.9	41.9	275	269.7	53.6
36	35.3	07.0	96	94.2	18.7	156	153.0	30.4	216	211.8	42.1	276	270.7	53.8
37	36.3	07.2	97	95.1	18.9	157	154.0	30.6	217	212.8	42.3	277	271.7	54.0
38	37.3	07.4	98	96.1	19.1	158	155.0	30.8	218	213.8	42.5	278	272.7	54.2
39	38.2	07.6	99	97.1	19.3	159	155.9	31.0	219	214.8	42.7	279	273.6	54.4
40	39.2	07.8	100	98.1	19.5	160	156.9	31.2	220	215.8	42.9	280	274.6	54.6
41	40.2	08.0	101	99.1	19.7	161	157.9	31.4	221	216.7	43.1	281	275.6	54.8
42	41.2	08.2	102	100.0	19.9	162	158.9	31.6	222	217.7	43.3	282	276.6	55.0
43	42.2	08.4	103	101.0	20.1	163	159.9	31.8	223	218.7	43.5	283	277.6	55.2
44	43.2	08.6	104	102.0	20.3	164	160.8	32.0	224	219.7	43.7	284	278.5	55.4
45	44.1	08.8	105	103.0	20.5	165	161.8	32.2	225	220.7	43.9	285	279.5	55.6
46	45.1	09.0	106	104.0	20.7	166	162.8	32.4	226	221.7	44.1	286	280.5	55.8
47	46.1	09.2	107	104.9	20.9	167	163.8	32.6	227	222.6	44.3	287	281.5	56.0
48	47.1	09.4	108	105.9	21.1	168	164.8	32.8	228	223.6	44.5	288	282.5	56.2
49	48.1	09.6	109	106.9	21.3	169	165.7	33.0	229	224.6	44.7	289	283.4	56.4
50	49.0	09.8	110	107.9	21.5	170	166.7	33.2	230	225.6	44.9	290	284.4	56.6
51	50.0	10.0	111	108.9	21.7	171	167.7	33.4	231	226.6	45.1	291	285.4	56.8
52	51.0	10.1	112	109.8	21.9	172	168.7	33.6	232	227.5	45.3	292	286.4	57.0
53	52.0	10.3	113	110.8	22.0	173	169.7	33.8	233	228.5	45.5	293	287.4	57.2
54	53.0	10.5	114	111.8	22.2	174	170.7	34.0	234	229.5	45.7	294	288.3	57.4
55	53.9	10.7	115	112.8	22.4	175	171.6	34.1	235	230.5	45.8	295	289.3	57.6
56	54.9	10.9	116	113.8	22.6	176	172.6	34.3	236	231.5	46.0	296	290.3	57.7
57	55.9	11.1	117	114.7	22.8	177	173.6	34.5	237	232.4	46.2	297	291.3	57.9
58	56.9	11.3	118	115.7	23.0	178	174.6	34.7	238	233.4	46.4	298	292.3	58.1
59	57.9	11.5	119	116.7	23.2	179	175.6	34.9	239	234.4	46.6	299	293.3	58.3
60	58.8	11.7	120	117.7	23.4	180	176.5	35.1	240	235.4	46.8	300	294.2	58.5
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Difference of Latitude and Departure for 1 ¼ Point.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	01.0	00.2	61	59.2	14.8	121	117.4	29.4	181	175.6	44.0	241	233.8	58.6
2	01.9	00.5	62	60.1	15.1	122	118.3	29.6	182	176.5	44.2	242	234.7	58.8
3	02.9	00.7	63	61.1	15.3	123	119.3	29.9	183	177.5	44.5	243	235.7	59.0
4	03.9	01.0	64	62.1	15.6	124	120.3	30.1	184	178.5	44.7	244	236.7	59.3
5	04.9	01.2	65	63.1	15.8	125	121.3	30.4	185	179.5	45.0	245	237.7	59.5
6	05.8	01.5	66	64.0	16.0	126	122.2	30.6	186	180.4	45.2	246	238.6	59.8
7	06.8	01.7	67	65.0	16.3	127	123.2	30.9	187	181.4	45.4	247	239.6	60.0
8	07.8	01.9	68	66.0	16.5	128	124.2	31.1	188	182.4	45.7	248	240.6	60.3
9	08.7	02.2	69	66.9	16.8	129	125.1	31.3	189	183.3	45.9	249	241.5	60.5
10	09.7	02.4	70	67.9	17.0	130	126.1	31.6	190	184.3	46.2	250	242.5	60.7
11	10.7	02.7	71	68.9	17.3	131	127.1	31.8	191	185.3	46.4	251	243.5	61.0
12	11.6	02.9	72	69.8	17.5	132	128.0	32.1	192	186.2	46.7	252	244.5	61.2
13	12.6	03.2	73	70.8	17.7	133	129.0	32.3	193	187.2	46.9	253	245.4	61.5
14	13.6	03.4	74	71.8	18.0	134	130.0	32.6	194	188.2	47.1	254	246.4	61.7
15	14.6	03.6	75	72.8	18.2	135	131.0	32.8	195	189.2	47.4	255	247.4	62.0
16	15.5	03.9	76	73.7	18.5	136	131.9	33.0	196	190.1	47.6	256	248.3	62.2
17	16.5	04.1	77	74.7	18.7	137	132.9	33.3	197	191.1	47.9	257	249.3	62.5
18	17.5	04.4	78	75.7	19.0	138	133.9	33.5	198	192.1	48.1	258	250.3	62.7
19	18.4	04.6	79	76.6	19.2	139	134.8	33.8	199	193.0	48.4	259	251.2	62.9
20	19.4	04.9	80	77.6	19.4	140	135.8	34.0	200	194.0	48.6	260	252.2	63.2
21	20.4	05.1	81	78.6	19.7	141	136.8	34.3	201	195.0	48.8	261	253.2	63.4
22	21.3	05.3	82	79.5	19.9	142	137.7	34.5	202	195.9	49.1	262	254.2	63.7
23	22.3	05.6	83	80.5	20.2	143	138.7	34.7	203	196.9	49.3	263	255.1	63.9
24	23.3	05.8	84	81.5	20.4	144	139.7	35.0	204	197.9	49.6	264	256.1	64.2
25	24.3	06.1	85	82.5	20.7	145	140.7	35.2	205	198.9	49.8	265	257.1	64.4
26	25.2	06.3	86	83.4	20.9	146	141.6	35.5	206	199.8	50.1	266	258.0	64.6
27	26.2	06.6	87	84.4	21.1	147	142.6	35.7	207	200.8	50.3	267	259.0	64.9
28	27.2	06.8	88	85.4	21.4	148	143.6	36.0	208	201.8	50.5	268	260.0	65.1
29	28.1	07.0	89	86.3	21.6	149	144.5	36.2	209	202.7	50.8	269	260.9	65.4
30	29.1	07.3	90	87.3	21.9	150	145.5	36.5	210	203.7	51.0	270	261.9	65.6
31	30.1	07.5	91	88.3	22.1	151	146.5	36.7	211	204.7	51.3	271	262.9	65.9
32	31.0	07.8	92	89.2	22.4	152	147.4	36.9	212	205.6	51.5	272	263.9	66.1
33	32.0	08.0	93	90.2	22.6	153	148.4	37.2	213	206.6	51.8	273	264.8	66.3
34	33.0	08.3	94	91.2	22.8	154	149.4	37.4	214	207.6	52.0	274	265.8	66.6
35	34.0	08.5	95	92.2	23.1	155	150.4	37.7	215	208.6	52.2	275	266.8	66.8
36	34.9	08.7	96	93.1	23.3	156	151.3	37.9	216	209.5	52.5	276	267.7	67.1
37	35.9	09.0	97	94.1	23.6	157	152.3	38.2	217	210.5	52.7	277	268.7	67.3
38	36.9	09.2	98	95.1	23.8	158	153.3	38.4	218	211.5	53.0	278	269.7	67.6
39	37.8	09.5	99	96.0	24.1	159	154.2	38.6	219	212.4	53.2	279	270.6	67.8
40	38.8	09.7	100	97.0	24.3	160	155.2	38.9	220	213.4	53.5	280	271.6	68.0
41	39.8	10.0	101	98.0	24.5	161	156.2	39.1	221	214.4	53.7	281	272.6	68.3
42	40.7	10.2	102	98.9	24.8	162	157.1	39.4	222	215.4	53.9	282	273.6	68.5
43	41.7	10.4	103	99.9	25.0	163	158.1	39.6	223	216.3	54.2	283	274.5	68.8
44	42.7	10.7	104	100.9	25.3	164	159.1	39.9	224	217.3	54.4	284	275.5	69.0
45	43.7	10.9	105	101.9	25.5	165	160.1	40.1	225	218.3	54.7	285	276.5	69.3
46	44.6	11.2	106	102.8	25.8	166	161.0	40.3	226	219.2	54.9	286	277.4	69.5
47	45.6	11.4	107	103.8	26.0	167	162.0	40.6	227	220.2	55.2	287	278.4	69.7
48	46.6	11.7	108	104.8	26.2	168	163.0	40.8	228	221.2	55.4	288	279.4	70.0
49	47.5	11.9	109	105.7	26.5	169	163.9	41.1	229	222.1	55.6	289	280.3	70.2
50	48.5	12.2	110	106.7	26.7	170	164.9	41.3	230	223.1	55.9	290	281.3	70.5
51	49.5	12.4	111	107.7	27.0	171	165.9	41.6	231	224.1	56.1	291	282.3	70.7
52	50.4	12.6	112	108.6	27.2	172	166.8	41.8	232	225.1	56.4	292	283.3	71.0
53	51.4	12.9	113	109.6	27.5	173	167.8	42.0	233	226.0	56.6	293	284.2	71.2
54	52.4	13.1	114	110.6	27.7	174	168.8	42.3	234	227.0	56.9	294	285.2	71.4
55	53.4	13.4	115	111.6	27.9	175	169.8	42.5	235	228.0	57.1	295	286.2	71.7
56	54.3	13.6	116	112.5	28.2	176	170.7	42.8	236	228.9	57.3	296	287.1	71.9
57	55.3	13.9	117	113.5	28.4	177	171.7	43.0	237	229.9	57.6	297	288.1	72.2
58	56.3	14.1	118	114.5	28.7	178	172.7	43.3	238	230.9	57.8	298	289.1	72.4
59	57.2	14.3	119	115.4	28.9	179	173.6	43.5	239	231.8	58.1	299	290.0	72.7
60	58.2	14.6	120	116.4	29.2	180	174.6	43.7	240	232.8	58.3	300	291.0	72.9
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Difference of Latitude and Departure for 1 ½ Point.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	01.0	00.3	61	58.4	17.7	121	115.8	35.1	181	173.2	52.5	241	230.6	70.0
2	01.9	00.6	62	59.3	18.0	122	116.8	35.4	182	174.2	52.8	242	231.6	70.2
3	02.9	00.9	63	60.3	18.3	123	117.7	35.7	183	175.1	53.1	243	232.5	70.5
4	03.8	01.2	64	61.2	18.6	124	118.7	36.0	184	176.1	53.4	244	233.5	70.8
5	04.8	01.5	65	62.2	18.9	125	119.6	36.3	185	177.0	53.7	245	234.5	71.1
6	05.7	01.7	66	63.2	19.2	126	120.6	36.6	186	178.0	54.0	246	235.4	71.4
7	06.7	02.0	67	64.1	19.4	127	121.5	36.9	187	179.0	54.3	247	236.4	71.7
8	07.7	02.3	68	65.1	19.7	128	122.5	37.2	188	179.9	54.6	248	237.3	72.0
9	08.6	02.6	69	66.0	20.0	129	123.5	37.4	189	180.9	54.9	249	238.3	72.3
10	09.6	02.9	70	67.0	20.3	130	124.4	37.7	190	181.8	55.1	250	239.2	72.6
11	10.5	03.2	71	67.9	20.6	131	125.4	38.0	191	182.8	55.4	251	240.2	72.9
12	11.5	03.5	72	68.9	20.9	132	126.3	38.3	192	183.7	55.7	252	241.2	73.1
13	12.4	03.8	73	69.9	21.2	133	127.3	38.6	193	184.7	56.0	253	242.1	73.4
14	13.4	04.1	74	70.8	21.5	134	128.2	38.9	194	185.7	56.3	254	243.1	73.7
15	14.4	04.4	75	71.8	21.8	135	129.2	39.2	195	186.6	56.6	255	244.0	74.0
16	15.3	04.6	76	72.7	22.1	136	130.1	39.5	196	187.6	56.9	256	245.0	74.3
17	16.3	04.9	77	73.7	22.3	137	131.1	39.8	197	188.5	57.2	257	245.9	74.6
18	17.2	05.2	78	74.6	22.6	138	132.1	40.1	198	189.5	57.5	258	246.9	74.9
19	18.2	05.5	79	75.6	22.9	139	133.0	40.3	199	190.4	57.8	259	247.9	75.2
20	19.1	05.8	80	76.6	23.2	140	134.0	40.6	200	191.4	58.1	260	248.8	75.5
21	20.1	06.1	81	77.5	23.5	141	134.9	40.9	201	192.3	58.4	261	249.8	75.8
22	21.1	06.4	82	78.5	23.8	142	135.9	41.2	202	193.3	58.6	262	250.7	76.0
23	22.0	06.7	83	79.4	24.1	143	136.8	41.5	203	194.3	58.9	263	251.7	76.3
24	23.0	07.0	84	80.4	24.4	144	137.8	41.8	204	195.2	59.2	264	252.6	76.6
25	23.9	07.3	85	81.3	24.7	145	138.8	42.1	205	196.2	59.5	265	253.6	76.9
26	24.9	07.5	86	82.3	25.0	146	139.7	42.4	206	197.1	59.8	266	254.6	77.2
27	25.8	07.8	87	83.3	25.2	147	140.7	42.7	207	198.1	60.1	267	255.5	77.5
28	26.8	08.1	88	84.2	25.5	148	141.6	43.0	208	199.0	60.4	268	256.5	77.8
29	27.8	08.4	89	85.2	25.8	149	142.6	43.2	209	200.0	60.7	269	257.4	78.1
30	28.7	08.7	90	86.1	26.1	150	143.5	43.5	210	201.0	61.0	270	258.4	78.4
31	29.7	09.0	91	87.1	26.4	151	144.5	43.8	211	201.9	61.2	271	259.3	78.7
32	30.6	09.3	92	88.0	26.7	152	145.5	44.1	212	202.9	61.5	272	260.3	79.0
33	31.6	09.6	93	89.0	27.0	153	146.4	44.4	213	203.8	61.8	273	261.2	79.2
34	32.5	09.9	94	90.0	27.3	154	147.4	44.7	214	204.8	62.1	274	262.2	79.5
35	33.5	10.2	95	90.9	27.6	155	148.3	45.0	215	205.7	62.4	275	263.2	79.8
36	34.5	10.4	96	91.9	27.9	156	149.3	45.3	216	206.7	62.7	276	264.1	80.1
37	35.4	10.7	97	92.8	28.2	157	150.2	45.6	217	207.7	63.0	277	265.1	80.4
38	36.4	11.0	98	93.8	28.4	158	151.2	45.9	218	208.6	63.3	278	266.0	80.7
39	37.3	11.3	99	94.7	28.7	159	152.2	46.1	219	209.6	63.6	279	267.0	81.0
40	38.3	11.6	100	95.7	29.0	160	153.1	46.4	220	210.5	63.9	280	267.9	81.3
41	39.2	11.9	101	96.7	29.3	161	154.1	46.7	221	211.5	64.1	281	268.9	81.6
42	40.2	12.2	102	97.6	29.6	162	155.0	47.0	222	212.4	64.4	282	269.9	81.9
43	41.2	12.5	103	98.6	29.9	163	156.0	47.3	223	213.4	64.7	283	270.8	82.1
44	42.1	12.8	104	99.5	30.2	164	156.9	47.6	224	214.4	65.0	284	271.8	82.4
45	43.1	13.1	105	100.5	30.5	165	157.9	47.9	225	215.3	65.3	285	272.7	82.7
46	44.0	13.3	106	101.4	30.8	166	158.9	48.2	226	216.3	65.6	286	273.7	83.0
47	45.0	13.6	107	102.4	31.1	167	159.8	48.5	227	217.2	65.9	287	274.6	83.3
48	45.9	13.9	108	103.4	31.4	168	160.8	48.8	228	218.2	66.2	288	275.6	83.6
49	46.9	14.2	109	104.3	31.6	169	161.7	49.1	229	219.1	66.5	289	276.6	83.9
50	47.9	14.5	110	105.3	31.9	170	162.7	49.3	230	220.1	66.8	290	277.5	84.2
51	48.8	14.8	111	106.2	32.2	171	163.6	49.6	231	221.1	67.0	291	278.5	84.5
52	49.8	15.1	112	107.2	32.5	172	164.6	49.9	232	222.0	67.3	292	279.4	84.8
53	50.7	15.4	113	108.1	32.8	173	165.6	50.2	233	223.0	67.6	293	280.4	85.0
54	51.7	15.7	114	109.1	33.1	174	166.5	50.5	234	223.9	67.9	294	281.3	85.3
55	52.6	16.0	115	110.1	33.4	175	167.5	50.8	235	224.9	68.2	295	282.3	85.6
56	53.6	16.3	116	111.0	33.7	176	168.4	51.1	236	225.8	68.5	296	283.3	85.9
57	54.5	16.5	117	112.0	34.0	177	169.4	51.4	237	226.8	68.8	297	284.2	86.2
58	55.5	16.8	118	112.9	34.2	178	170.3	51.7	238	227.8	69.1	298	285.2	86.5
59	56.5	17.1	119	113.9	34.5	179	171.3	52.0	239	228.7	69.4	299	286.1	86.8
60	57.4	17.4	120	114.8	34.8	180	172.3	52.2	240	229.7	69.7	300	287.1	87.1
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Difference of Latitude and Departure for 1 ¾ Point.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.9	00.3	61	57.4	20.5	121	113.9	40.8	181	170.4	61.0	241	226.9	81.2
2	01.9	00.7	62	58·4	20.9	122	114.9	41.1	182	171.4	61.3	242	227.8	81.5
3	02.8	01.0	63	59.3	21.2	123	115.8	41.4	183	172.3	61.6	243	228.8	81.9
4	03.8	01.3	64	60.3	21.6	124	116.7	41.8	184	173.2	62.0	244	229.7	82.2
5	04.7	01.7	65	61.2	21.9	125	117.7	42.1	185	174.2	62.3	245	230.7	82.5
6	05.6	02.0	66	62.1	22.2	126	118.6	42.4	186	175.1	62.7	246	231.6	82.9
7	06.6	02.4	67	63.1	22.6	127	119.6	42.8	187	176.1	63.0	247	232.6	83.2
8	07.5	02.7	68	64.0	22.9	128	120.5	43.1	188	177.0	63.3	248	233.5	83.5
9	08.5	03.0	69	65.0	23.2	129	121.5	43.5	189	177.9	63.7	249	234.4	83.9
10	09.4	03.4	70	65.9	23.6	130	122.4	43.8	190	178.9	64.0	250	235.4	84.2
11	10.4	03.7	71	66.8	23.9	131	123.3	44.1	191	179.8	64.3	251	236.3	84.6
12	11.3	04.0	72	67.8	24.3	132	124.3	44.5	192	180.8	64.7	252	237.3	84.9
13	12.2	04.4	73	68.7	24.6	133	125.2	44.8	193	181.7	65.0	253	238.2	85.2
14	13.2	04.7	74	69.7	24.9	134	126.2	45.1	194	182.7	65.4	254	239.1	85.6
15	14.1	05.1	75	70.6	25.3	135	127.1	45.5	195	183.6	65.7	255	240.1	85.9
16	15.1	05.4	76	71.6	25.6	136	128.0	45.8	196	184.5	66.0	256	241.0	86.2
17	16.0	05.7	77	72.5	25.9	137	129.0	46.1	197	185.5	66.4	257	242.0	86.6
18	17.0	06.1	78	73.4	26.3	138	129.9	46.5	198	186.4	66.7	258	242.9	86.9
19	17.9	06.4	79	74.4	26.6	139	130.9	46.8	199	187.4	67.0	259	243.9	87.2
20	18.8	06.7	80	75.3	26.9	140	131.8	47.2	200	188.3	67.4	260	244.8	87.6
21	19.8	07.1	81	76.3	27.3	141	132.8	47.5	201	189.2	67.7	261	245.7	87.9
22	20.7	07.4	82	77.2	27.6	142	133.7	47.8	202	190.2	68.0	262	246.7	88.3
23	21.7	07.7	83	78.1	28.0	143	134.6	48.2	203	191.1	68.4	263	247.6	88.6
24	22.6	08.1	84	79.1	28.3	144	135.6	48.5	204	192.1	68.7	264	248.6	88.9
25	23.5	08.4	85	80.0	28.6	145	136.5	48.8	205	193.0	69.1	265	249.5	89.3
26	24.5	08.8	86	81.0	29.0	146	137.5	49.2	206	194.0	69.4	266	250.4	89.6
27	25.4	09.1	87	81.9	29.3	147	138.4	49.5	207	194.9	69.7	267	251.4	89.9
28	26.4	09.4	88	82.9	29.6	148	139.3	49.9	208	195.8	70.1	268	252.3	90.3
29	27.3	09.8	89	83.8	30.0	149	140.3	50.2	209	196.8	70.4	269	253.3	90.6
30	28.2	10.1	90	84.7	30.3	150	141.2	50.5	210	197.7	70.7	270	254.2	91.0
31	29.2	10.4	91	85.7	30.7	151	142.2	50.9	211	198.7	71.1	271	255.2	91.3
32	30.1	10.8	92	86.6	31.0	152	143.1	51.2	212	199.6	71.4	272	256.1	91.6
33	31.1	11.1	93	87.6	31.3	153	144.1	51.5	213	200.5	71.8	273	257.0	92.0
34	32.0	11.5	94	88.5	31.7	154	145.0	51.9	214	201.5	72.1	274	258.0	92.3
35	33.0	11.8	95	89.4	32.0	155	145.9	52.2	215	202.4	72.4	275	258.9	92.6
36	33.9	12.1	96	90.4	32.3	156	146.9	52.5	216	203.4	72.8	276	259.9	93.0
37	34.8	12.5	97	91.3	32.7	157	147.8	52.9	217	204.3	73.1	277	260.8	93.3
38	35.8	12.8	98	92.3	33.0	158	148.8	53.2	218	205.3	73.4	278	261.7	93.7
39	36.7	13.1	99	93.2	33.3	159	149.7	53.6	219	206.2	73.8	279	262.7	94.0
40	37.7	13.5	100	94.2	33.7	160	150.6	53.9	220	207.1	74.1	280	263.6	94.3
41	38.6	13.8	101	95.1	34.0	161	151.6	54.2	221	208.1	74.4	281	264.6	94.7
42	39.5	14.1	102	96.0	34.4	162	152.5	54.6	222	209.0	74.8	282	265.5	95.0
43	40.5	14.5	103	97.0	34.7	163	153.5	54.9	223	210.0	75.1	283	266.5	95.3
44	41.4	14.8	104	97.9	35.0	164	154.4	55.2	224	210.9	75.5	284	267.4	95.7
45	42.4	15.2	105	98.9	35.4	165	155.3	55.6	225	211.8	75.8	285	268.3	96.0
46	43.3	15.5	106	99.8	35.7	166	156.3	55.9	226	212.8	76.1	286	269.3	96.3
47	44.3	15.8	107	100.7	36.0	167	157.2	56.3	227	213.7	76.5	287	270.2	96.7
48	45.2	16.2	108	101.7	36.4	168	158.2	56.6	228	214.7	76.8	288	271.2	97.0
49	46.1	16.5	109	102.6	36.7	169	159.1	56.9	229	215.6	77.1	289	272.1	97.4
50	47.1	16.8	110	103.6	37.1	170	160.1	57.3	230	216.5	77.5	290	273.0	97.7
51	48.0	17.2	111	104.5	37.4	171	161.0	57.6	231	217.5	77.8	291	274.0	98.0
52	49.0	17.5	112	105.4	37.7	172	161.9	57.9	232	218.4	78.2	292	274.9	98.4
53	49.9	17.9	113	106.4	38.1	173	162.9	58.3	233	219.4	78.5	293	275.9	98.7
54	50.8	18.2	114	107.3	38.4	174	163.8	58.6	234	220.3	78.8	294	276.8	99.0
55	51.8	18.5	115	108.3	38.7	175	164.8	59.0	235	221.3	79.2	295	277.7	99.4
56	52.7	18.9	116	109.2	39.1	176	165.7	59.3	236	222.2	79.5	296	278.7	99.7
57	53.7	19.2	117	110.2	39.4	177	166.6	59.6	237	223.1	79.8	297	279.6	100.1
58	54.6	19.5	118	111.1	39.7	178	167.6	60.0	238	224.1	80.2	298	280.6	100.4
59	55.5	19.9	119	112.0	40.1	179	168.5	60.3	239	225.0	80.5	299	281.5	100.7
60	56.5	20.2	120	113.0	40.4	180	169.5	60.6	240	226.0	80.8	300	282.5	101.1
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Difference of Latitude and Departure for 2 Points.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.9	00.4	61	56.4	23.3	121	111.8	46.3	181	167.2	69.3	241	222.7	92.2
2	01.8	00.8	62	57.3	23.7	122	112.7	46.7	182	168.2	69.7	242	223.6	92.6
3	02.8	01.1	63	58.2	24.1	123	113.6	47.1	183	169.1	70.0	243	224.5	93.0
4	03.7	01.5	64	59.1	24.5	124	114.6	47.5	184	170.0	70.4	244	225.4	93.4
5	04.6	01.9	65	60.1	24.9	125	115.5	47.8	185	170.9	70.8	245	226.4	93.8
6	05.5	02.3	66	61.0	25.3	126	116.4	48.2	186	171.8	71.2	246	227.3	94.1
7	06.5	02.7	67	61.9	25.6	127	117.3	48.6	187	172.8	71.6	247	228.2	94.5
8	07.4	03.1	68	62.8	26.0	128	118.3	49.0	188	173.7	71.9	248	229.1	94.9
9	08.3	03.4	69	63.8	26.4	129	119.2	49.4	189	174.6	72.3	249	230.1	95.3
10	09.2	03.8	70	64.7	26.8	130	120.1	49.8	190	175.5	72.7	250	231.0	95.7
11	10.2	04.2	71	65.6	27.2	131	121.0	50.1	191	176.5	73.1	251	231.9	96.1
12	11.1	04.6	72	66.5	27.6	132	122.0	50.5	192	177.4	73.5	252	232.8	96.4
13	12.0	05.0	73	67.4	27.9	133	122.9	50.9	193	178.3	73.9	253	233.7	96.8
14	12.9	05.4	74	68.4	28.3	134	123.8	51.3	194	179.2	74.2	254	234.7	97.2
15	13.9	05.7	75	69.3	28.7	135	124.7	51.7	195	180.2	74.6	255	235.6	97.6
16	14.8	06.1	76	70.2	29.1	136	125.7	52.0	196	181.1	75.0	256	236.5	98.0
17	15.7	06.5	77	71.1	29.5	137	126.6	52.4	197	182.0	75.4	257	237.4	98.4
18	16.6	06.9	78	72.1	29.9	138	127.5	52.8	198	182.9	75.8	258	238.4	98.7
19	17.6	07.3	79	73.0	30.2	139	128.4	53.2	199	183.9	76.2	259	239.3	99.1
20	18.5	07.7	80	73.9	30.6	140	129.3	53.6	200	184.8	76.5	260	240.2	99.5
21	19.4	08.0	81	74.8	31.0	141	130.3	54.0	201	185.7	76.9	261	241.1	99.9
22	20.3	08.4	82	75.8	31.4	142	131.2	54.3	202	186.6	77.3	262	242.1	100.3
23	21.3	08.8	83	76.7	31.8	143	132.1	54.7	203	187.6	77.7	263	243.0	100.6
24	22.2	09.2	84	77.6	32.1	144	133.0	55.1	204	188.5	78.1	264	243.9	101.0
25	23.1	09.6	85	78.5	32.5	145	134.0	55.5	205	189.4	78.5	265	244.8	101.4
26	24.0	10.0	86	79.5	32.9	146	134.9	55.9	206	190.3	78.8	266	245.8	101.8
27	24.9	10.3	87	80.4	33.3	147	135.8	56.3	207	191.2	79.2	267	246.7	102.2
28	25.9	10.7	88	81.3	33.7	148	136.7	56.6	208	192.2	79.6	268	247.6	102.6
29	26.8	11.1	89	82.2	34.1	149	137.7	57.0	209	193.1	80.0	269	248.5	102.9
30	27.7	11.5	90	83.2	34.4	150	138.6	57.4	210	194.0	80.4	270	249.5	103.3
31	28.6	11.9	91	84.1	34.8	151	139.5	57.8	211	194.9	80.8	271	250.4	103.7
32	29.6	12.2	92	85.0	35.2	152	140.4	58.2	212	195.9	81.1	272	251.3	104.1
33	30.5	12.6	93	85.9	35.6	153	141.4	58.6	213	196.8	81.5	273	252.2	104.5
34	31.4	13.0	94	86.8	36.0	154	142.3	58.9	214	197.7	81.9	274	253.1	104.9
35	32.3	13.4	95	87.8	36.4	155	143.2	59.3	215	198.6	82.3	275	254.1	105.2
36	33.3	13.8	96	88.7	36.7	156	144.1	59.7	216	199.6	82.7	276	255.0	105.6
37	34.2	14.2	97	89.6	37.1	157	145.1	60.1	217	200.5	83.0	277	255.9	106.0
38	35.1	14.5	98	90.5	37.5	158	146.0	60.5	218	201.4	83.4	278	256.8	106.4
39	36.0	14.9	99	91.5	37.9	159	146.9	60.9	219	202.3	83.8	279	257.8	106.8
40	37.0	15.3	100	92.4	38.3	160	147.8	61.2	220	203.3	84.2	280	258.7	107.2
41	37.9	15.7	101	93.3	38.7	161	148.7	61.6	221	204.2	84.6	281	259.6	107.5
42	38.8	16.1	102	94.2	39.0	162	149.7	62.0	222	205.1	85.0	282	260.5	107.9
43	39.7	16.5	103	95.2	39.4	163	150.6	62.4	223	206.0	85.3	283	261.5	108.3
44	40.6	16.8	104	96.1	39.8	164	151.5	62.8	224	207.0	85.7	284	262.4	108.7
45	41.6	17.2	105	97.0	40.2	165	152.4	63.1	225	207.9	86.1	285	263.3	109.1
46	42.5	17.6	106	97.9	40.6	166	153.4	63.5	226	208.8	86.5	286	264.2	109.5
47	43.4	18.0	107	98.9	41.0	167	154.3	63.9	227	209.7	86.9	287	265.2	109.8
48	44.4	18.4	108	99.8	41.3	168	155.2	64.3	228	210.6	87.3	288	266.1	110.2
49	45.3	18.8	109	100.7	41.7	169	156.1	64.7	229	211.6	87.6	289	267.0	110.6
50	46.2	19.1	110	101.6	42.1	170	157.1	65.1	230	212.5	88.0	290	267.9	111.0
51	47.1	19.5	111	102.6	42.5	171	158.0	65.4	231	213.4	88.4	291	268.9	111.4
52	48.0	19.9	112	103.5	42.9	172	158.9	65.8	232	214.3	88.8	292	269.8	111.7
53	49.0	20.3	113	104.4	43.2	173	159.8	66.2	233	215.3	89.2	293	270.7	112.1
54	49.9	20.7	114	105.3	43.6	174	160.8	66.6	234	216.2	89.6	294	271.6	112.5
55	50.8	21.0	115	106.3	44.0	175	161.7	67.0	235	217.1	89.9	295	272.5	112.9
56	51.7	21.4	116	107.2	44.4	176	162.6	67.4	236	218.0	90.3	296	273.5	113.3
57	52.7	21.8	117	108.1	44.8	177	163.5	67.7	237	219.0	90.7	297	274.4	113.7
58	53.6	22.2	118	109.0	45.2	178	164.5	68.1	238	219.9	91.1	298	275.3	114.0
59	54.5	22.6	119	109.9	45.5	179	165.4	68.5	239	220.8	91.5	299	276.2	114.4
60	55.4	23.0	120	110.9	45.9	180	166.3	68.9	240	221.7	91.8	300	277.2	114.8
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Difference of Latitude and Departure for 2 ¼ Points.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.9	00.4	61	55.1	26.1	121	109.4	51.7	181	163.6	77.4	241	217.9	103.0
2	01.8	00.9	62	56.0	26.5	122	110.3	52.2	182	164.5	77.8	242	218.8	103.5
3	02.7	01.3	63	57.0	26.9	123	111.2	52.6	183	165.4	78.3	243	219.7	103.9
4	03.6	01.7	64	57.9	27.4	124	112.1	53.0	184	166.3	78.7	244	220.6	104.3
5	04.5	02.1	65	58.8	27.8	125	113.0	53.5	185	167.2	79.1	245	221.5	104.8
6	05.4	02.6	66	59.7	28.2	126	113.9	53.9	186	168.1	79.5	246	222.4	105.2
7	06.3	03.0	67	60.6	28.6	127	114.8	54.3	187	169.0	80.0	247	223.3	105.6
8	07.2	03.4	68	61.5	29.1	128	115.7	54.7	188	169.9	80.4	248	224.2	106.0
9	08.1	03.8	69	62.4	29.5	129	116.6	55.2	189	170.9	80.8	249	225.1	106.5
10	09.0	04.3	70	63.3	29.9	130	117.5	55.6	190	171.8	81.2	250	226.0	106.9
11	09.9	04.7	71	64.2	30.4	131	118.4	56.0	191	172.7	81.7	251	226.9	107.3
12	10.8	05.1	72	65.1	30.8	132	119.3	56.4	192	173.6	82.1	252	227.8	107.8
13	11.8	05.6	73	66.0	31.2	133	120.2	56.9	193	174.5	82.5	253	228.7	108.2
14	12.7	06.0	74	66.9	31.6	134	121.1	57.3	194	175.4	83.0	254	229.6	108.6
15	13.6	06.4	75	67.8	32.1	135	122.0	57.7	195	176.3	83.4	255	230.5	109.0
16	14.5	06.8	76	68.7	32.5	136	122.9	58.2	196	177.2	83.8	256	231.4	109.5
17	15.4	07.3	77	69.6	32.9	137	123.8	58.6	197	178.1	84.2	257	232.3	109.9
18	16.3	07.7	78	70.5	33.4	138	124.7	59.0	198	179.0	84.7	258	233.2	110.3
19	17.2	08.1	79	71.4	33.8	139	125.7	59.4	199	179.9	85.1	259	234.1	110.7
20	18.1	08.6	80	72.3	34.2	140	126.6	59.9	200	180.8	85.5	260	235.0	111.2
21	19.0	09.0	81	73.2	34.6	141	127.5	60.3	201	181.7	85.9	261	235.9	111.6
22	19.9	09.4	82	74.1	35.1	142	128.4	60.7	202	182.6	86.4	262	236.8	112.0
23	20.8	09.8	83	75.0	35.5	143	129.3	61.2	203	183.5	86.8	263	237.7	112.5
24	21.7	10.3	84	75.9	35.9	144	130.2	61.6	204	184.4	87.2	264	238.7	112.9
25	22.6	10.7	85	76.8	36.3	145	131.1	62.0	205	185.3	87.7	265	239.6	113.3
26	23.5	11.1	86	77.7	36.8	146	132.0	62.4	206	186.2	88.1	266	240.5	113.7
27	24.4	11.5	87	78.6	37.2	147	132.9	62.9	207	187.1	88.5	267	241.4	114.2
28	25.3	12.0	88	79.6	37.6	148	133.8	63.3	208	188.0	88.9	268	242.3	114.6
29	26.2	12.4	89	80.5	38.1	149	134.7	63.7	209	188.9	89.4	269	243.2	115.0
30	27.1	12.8	90	81.4	38.5	150	135.6	64.1	210	189.8	89.8	270	244.1	115.4
31	28.0	13.3	91	82.3	38.9	151	136.5	64.6	211	190.7	90.2	271	245.0	115.9
32	28.9	13.7	92	83.2	39.3	152	137.4	65.0	212	191.6	90.6	272	245.9	116.3
33	29.8	14.1	93	84.1	39.8	153	138.3	65.4	213	192.6	91.1	273	246.8	116.7
34	30.7	14.5	94	85.0	40.2	154	139.2	65.9	214	193.5	91.5	274	247.7	117.2
35	31.6	15.0	95	85.9	40.6	155	140.1	66.3	215	194.4	91.9	275	248.6	117.6
36	32.5	15.4	96	86.8	41.1	156	141.0	66.7	216	195.3	92.4	276	249.5	118.0
37	33.4	15.8	97	87.7	41.5	157	141.9	67.1	217	196.2	92.8	277	250.4	118.4
38	34.4	16.2	98	88.6	41.9	158	142.8	67.6	218	197.1	93.2	278	251.3	118.9
39	35.3	16.7	99	89.5	42.3	159	143.7	68.0	219	198.0	93.6	279	252.2	119.3
40	36.2	17.1	100	90.4	42.8	160	144.6	68.4	220	198.9	94.1	280	253.1	119.7
41	37.1	17.5	101	91.3	43.2	161	145.5	68.8	221	199.8	94.5	281	254.0	120.2
42	38.0	18.0	102	92.2	43.6	162	146.4	69.3	222	200.7	94.9	282	254.9	120.6
43	38.9	18.4	103	93.1	44.0	163	147.3	69.7	223	201.6	95.4	283	255.8	121.0
44	39.8	18.8	104	94.0	44.5	164	148.3	70.1	224	202.5	95.8	284	256.7	121.4
45	40.7	19.2	105	94.9	44.9	165	149.2	70.6	225	203.4	96.2	285	257.6	121.9
46	41.6	19.7	106	95.8	45.3	166	150.1	71.0	226	204.3	96.6	286	258.5	122.3
47	42.5	20.1	107	96.7	45.8	167	151.0	71.4	227	205.2	97.1	287	259.4	122.7
48	43.4	20.5	108	97.6	46.2	168	151.9	71.8	228	206.1	97.5	288	260.3	123.1
49	44.3	21.0	109	98.5	46.6	169	152.8	72.3	229	207.0	97.9	289	261.3	123.6
50	45.2	21.4	110	99.4	47.0	170	153.7	72.7	230	207.9	98.3	290	262.2	124.0
51	46.1	21.8	111	100.3	47.5	171	154.6	73.1	231	208.8	98.8	291	263.1	124.4
52	47.0	22.2	112	101.2	47.9	172	155.5	73.6	232	209.7	99.2	292	264.0	124.9
53	47.9	22.7	113	102.1	48.3	173	156.4	74.0	233	210.6	99.6	293	264.9	125.3
54	48.8	23.1	114	103.1	48.7	174	157.3	74.4	234	211.5	100.1	294	265.8	125.7
55	49.7	23.5	115	104.0	49.2	175	158.2	74.8	235	212.4	100.5	295	266.7	126.1
56	50.6	23.9	116	104.9	49.6	176	159.1	75.3	236	213.3	100.9	296	267.6	126.6
57	51.5	24.4	117	105.8	50.0	177	160.0	75.7	237	214.2	101.3	297	268.5	127.0
58	52.4	24.8	118	106.7	50.5	178	160.9	76.1	238	215.1	101.8	298	269.4	127.4
59	53.3	25.2	119	107.6	50.9	179	161.8	76.5	239	216.1	102.2	299	270.3	127.8
60	54.2	25.7	120	108.5	51.3	180	162.7	77.0	240	217.0	102.6	300	271.2	128.3
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

for 5 ¾ Points.

Difference of Latitude and Departure for 2 ½ Points.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.9	00.5	61	53.8	28.8	121	106.7	57.0	181	159.6	85.3	241	212.5	113.6
2	01.8	00.9	62	54.7	29.2	122	107.6	57.5	182	160.5	85.8	242	213.4	114.1
3	02.6	01.4	63	55.6	29.7	123	108.5	58.0	183	161.4	86.3	243	214.3	114.6
4	03.5	01.9	64	56.4	30.2	124	109.4	58.4	184	162.3	86.7	244	215.2	115.0
5	04.4	02.4	65	57.3	30.6	125	110.2	58.9	185	163.2	87.2	245	216.1	115.5
6	05.3	02.8	66	58.2	31.1	126	111.1	59.4	186	164.0	87.7	246	217.0	116.0
7	06.2	03.3	67	59.1	31.6	127	112.0	59.9	187	164.9	88.1	247	217.8	116.4
8	07.1	03.8	68	60.0	32.1	128	112.9	60.3	188	165.8	88.6	248	218.7	116.9
9	07.9	04.2	69	60.9	32.5	129	113.8	60.8	189	166.7	89.1	249	219.6	117.4
10	08.8	04.7	70	61.7	33.0	130	114.7	61.3	190	167.6	89.6	250	220.5	117.8
11	09.7	05.2	71	62.6	33.5	131	115.5	61.7	191	168.5	90.0	251	221.4	118.3
12	10.6	05.7	72	63.5	33.9	132	116.4	62.2	192	169.3	90.5	252	222.2	118.8
13	11.5	06.1	73	64.4	34.4	133	117.3	62.7	193	170.2	91.0	253	223.1	119.3
14	12.3	06.6	74	65.3	34.9	134	118.2	63.2	194	171.1	91.4	254	224.0	119.7
15	13.2	07.1	75	66.1	35.4	135	119.1	63.6	195	172.0	91.9	255	224.9	120.2
16	14.1	07.5	76	67.0	35.8	136	119.9	64.1	196	172.9	92.4	256	225.8	120.7
17	15.0	08.0	77	67.9	36.3	137	120.8	64.6	197	173.7	92.9	257	226.7	121.1
18	15.9	08.5	78	68.8	36.8	138	121.7	65.0	198	174.6	93.3	258	227.5	121.6
19	16.8	09.0	79	69.7	37.2	139	122.6	65.5	199	175.5	93.8	259	228.4	122.1
20	17.6	09.4	80	70.6	37.7	140	123.5	66.0	200	176.4	94.3	260	229.3	122.6
21	18.5	09.9	81	71.4	38.2	141	124.4	66.5	201	177.3	94.7	261	230.2	123.0
22	19.4	10.4	82	72.3	38.6	142	125.2	66.9	202	178.2	95.2	262	231.1	123.5
23	20.3	10.8	83	73.2	39.1	143	126.1	67.4	203	179.0	95.7	263	231.9	124.0
24	21.2	11.3	84	74.1	39.6	144	127.0	67.9	204	179.9	96.2	264	232.8	124.4
25	22.1	11.8	85	75.0	40.1	145	127.9	68.3	205	180.8	96.6	265	233.7	124.9
26	22.9	12.3	86	75.9	40.5	146	128.8	68.8	206	181.7	97.1	266	234.6	125.4
27	23.8	12.7	87	76.7	41.0	147	129.6	69.3	207	182.6	97.6	267	235.5	125.9
28	24.7	13.2	88	77.6	41.5	148	130.5	69.8	208	183.4	98.0	268	236.4	126.3
29	25.6	13.7	89	78.5	41.9	149	131.4	70.2	209	184.3	98.5	269	237.2	126.8
30	26.5	14.1	90	79.4	42.4	150	132.3	70.7	210	185.2	99.0	270	238.1	127.3
31	27.3	14.6	91	80.3	42.9	151	133.2	71.2	211	186.1	99.5	271	239.0	127.7
32	28.2	15.1	92	81.1	43.4	152	134.1	71.6	212	187.0	99.9	272	239.9	128.2
33	29.1	15.6	93	82.0	43.8	153	134.9	72.1	213	187.8	100.4	273	240.8	128.7
34	30.0	16.0	94	82.9	44.3	154	135.8	72.6	214	188.7	100.9	274	241.7	129.2
35	30.9	16.5	95	83.8	44.8	155	136.7	73.1	215	189.6	101.3	275	242.5	129.6
36	31.8	17.0	96	84.7	45.2	156	137.6	73.5	216	190.5	101.8	276	243.4	130.1
37	32.6	17.4	97	85.6	45.7	157	138.5	74.0	217	191.4	102.3	277	244.3	130.6
38	33.5	17.9	98	86·4	46.2	158	139.3	74.5	218	192.3	102.8	278	245.2	131.0
39	34.4	18.4	99	87.3	46.7	159	140.2	74.9	219	193.1	103.2	279	246.1	131.5
40	35.3	18.9	100	88.2	47.1	160	141.1	75.4	220	194.0	103.7	280	246.9	132.0
41	36.2	19.3	101	89.1	47.6	161	142.0	75.9	221	194.9	104.2	281	247.8	132.5
42	37.0	19.8	102	90.0	48.1	162	142.9	76.4	222	195.8	104.6	282	248.7	132.9
43	37.9	20.3	103	90.8	48.5	163	143.8	76.8	223	196.7	105.1	283	249.6	133.4
44	38.8	20.7	104	91.7	49.0	164	144.6	77.3	224	197.6	105.6	284	250.5	133.9
45	39.7	21.2	105	92.6	49.5	165	145.5	77.8	225	198.4	106.1	285	251.4	134.3
46	40.6	21.7	106	93.5	50.0	166	146.4	78.2	226	199.3	106.5	286	252.2	134.8
47	41.5	22.2	107	94.4	50.4	167	147.3	78.7	227	200.2	107.0	287	253.1	135.3
48	42.3	22.6	108	95.3	50.9	168	148.2	79.2	228	201.1	107.5	288	254.0	135.8
49	43.2	23.1	109	96.1	51.4	169	149.0	79.7	229	202.0	107.9	289	254.9	136.2
50	44.1	23.6	110	97.0	51.8	170	149.9	80.1	230	202.8	108.4	290	255.8	136.7
51	45.0	24.0	111	97.9	52.3	171	150.8	80.6	231	203.7	108.9	291	256.6	137.2
52	45.9	24.5	112	98.8	52.8	172	151.7	81.1	232	204.6	109.4	292	257.5	137.6
53	46.7	25.0	113	99.7	53.3	173	152.6	81.5	233	205.5	109.8	293	258.4	138.1
54	47.6	25.5	114	100.5	53.7	174	153.5	82.0	234	206.4	110.3	294	259.3	138.6
55	48.5	25.9	115	101.4	54.2	175	154.3	82.5	235	207.3	110.8	295	260.2	139.1
56	49.4	26.4	116	102.3	54.7	176	155.2	83.0	236	208.1	111.2	296	261.1	139.5
57	50.3	26.9	117	103.2	55.1	177	156.1	83.4	237	209.0	111.7	297	261.9	140.0
58	51.2	27.3	118	104.1	55.6	178	157.0	83.9	238	209.9	112.2	298	262.8	140.5
59	52.0	27.8	119	105.0	56.1	179	157.9	84.4	239	210.8	112.7	299	263.7	140.9
60	52.9	28.3	120	105.8	56.6	180	158.8	84.8	240	211.7	113.1	300	264.6	141.4
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

for 5 ½ Points.

Difference of Latititude and Departure for 2 $\frac{3}{4}$ Points.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.9	00.5	61	52.3	31.4	121	103.8	62.2	181	155.3	93.0	241	206.7	123.9
2	01.7	01.0	62	53.2	31.9	122	104.6	62.7	182	156.1	93.6	242	207.6	124.4
3	02.6	01.5	63	54.0	32.4	123	105.5	63.2	183	157.0	94.1	243	208.4	124.9
4	03.4	02.1	64	54.9	32.9	124	106.4	63.7	184	157.8	94.6	244	209.3	125.4
5	04.3	02.6	65	55.8	33.4	125	107.2	64.3	185	158.7	95.1	245	210.1	125.9
6	05.1	03.1	66	56.6	33.9	126	108.1	64.8	186	159.5	95.6	246	211.0	126.5
7	06.0	03.6	67	57.5	34.4	127	108.9	65.3	187	160.4	96.1	247	211.9	127.0
8	06.9	04.1	68	58.3	35.0	128	109.8	65.8	188	161.2	96.6	248	212.7	127.5
9	07.7	04.6	69	59.2	35.5	129	110.6	66.3	189	162.1	97.2	249	213.6	128.0
10	08.6	05.1	70	60.0	36.0	130	111.5	66.8	190	163.0	97.7	250	214.4	128.5
11	09.4	05.7	71	60.9	36.5	131	112.4	67.3	191	163.8	98.2	251	215.3	129.0
12	10.3	06.2	72	61.8	37.0	132	113.2	67.9	192	164.7	98.7	252	216.1	129.5
13	11.2	06.7	73	62.6	37.5	133	114.1	68.4	193	165.5	99.2	253	217.0	130.1
14	12.0	07.2	74	63.5	38.0	134	114.9	68.9	194	166.4	99.7	254	217.9	130.6
15	12.9	07.7	75	64.3	38.6	135	115.8	69.4	195	167.3	100.2	255	218.7	131.1
16	13.7	08.2	76	65.2	39.1	136	116.6	69.9	196	168.1	100.8	256	219.6	131.6
17	14.6	08.7	77	66.0	39.6	137	117.5	70.4	197	169.0	101.3	257	220.4	132.1
18	15.4	09.3	78	66.9	40.1	138	118.4	70.9	198	169.8	101.8	258	221.3	132.6
19	16.3	09.8	79	67.8	40.6	139	119.2	71.5	199	170.7	102.3	259	222.1	133.1
20	17.2	10.3	80	68.6	41.1	140	120.1	72.0	200	171.5	102.8	260	223.0	133.7
21	18.0	10.8	81	69.5	41.6	141	120.9	72.5	201	172.4	103.3	261	223.9	134.2
22	18.9	11.3	82	70.3	42.2	142	121.8	73.0	202	173.3	103.8	262	224.7	134.7
23	19.7	11.8	83	71.2	42.7	143	122.7	73.5	203	174.1	104.4	263	225.6	135.2
24	20.6	12.3	84	72.0	43.2	144	123.5	74.0	204	175.0	104.9	264	226.4	135.7
25	21.4	12.9	85	72.9	43.7	145	124.4	74.5	205	175.8	105.4	265	227.3	136.2
26	22.3	13.4	86	73.8	44.2	146	125.2	75.1	206	176.7	105.9	266	228.2	136.7
27	23.2	13.9	87	74.6	44.7	147	126.1	75.6	207	177.5	106.4	267	229.0	137.3
28	24.0	14.4	88	75.5	45.2	148	126.9	76.1	208	178.4	106.9	268	229.9	137.8
29	24.9	14.9	89	76.3	45.7	149	127.8	76.6	209	179.3	107.4	269	230.7	138.3
30	25.7	15.4	90	77.2	46.3	150	128.7	77.1	210	180.1	108.0	270	231.6	138.8
31	26.6	15.9	91	78.1	46.8	151	129.5	77.6	211	181.0	108.5	271	232.4	139.3
32	27.4	16.4	92	78.9	47.3	152	130.4	78.1	212	181.8	109.0	272	233.3	139.8
33	28.3	17.0	93	79.8	47.8	153	131.2	78.7	213	182.7	109.5	273	234.2	140.3
34	29.2	17.5	94	80.6	48.3	154	132.1	79.2	214	183.5	110.0	274	235.0	140.9
35	30.0	18.0	95	81.5	48.8	155	132.9	79.7	215	184.4	110.5	275	235.9	141.4
36	30.9	18.5	96	82.3	49.3	156	133.8	80.2	216	185.3	111.0	276	236.7	141.9
37	31.7	19.0	97	83.2	49.9	157	134.7	80.7	217	186.1	111.6	277	237.6	142.4
38	32.6	19.5	98	84.1	50.4	158	135.5	81.2	218	187.0	112.1	278	238.4	142.9
39	33.5	20.0	99	84.9	50.9	159	136.4	81.7	219	187.8	112.6	279	239.3	143.4
40	34.3	20.6	100	85.8	51.5	160	137.2	82.3	220	188.7	113.1	280	240.2	143.9
41	35.2	21.1	101	86.6	51.9	161	138.1	82.8	221	189.6	113.6	281	241.0	144.5
42	36.0	21.6	102	87.5	52.4	162	138.9	83.3	222	190.4	114.1	282	241.9	145.0
43	36.9	22.1	103	88.3	52.9	163	139.8	83.8	223	191.3	114.6	283	242.7	145.5
44	37.7	22.6	104	89.2	53.5	164	140.7	84.3	224	192.1	115.2	284	243.6	146.0
45	38.6	23.1	105	90.1	54.0	165	141.5	84.8	225	193.0	115.7	285	244.4	146.5
46	39.5	23.6	106	90.9	54.5	166	142.4	85.3	226	193.8	116.2	286	245.3	147.0
47	40.3	24.2	107	91.8	55.0	167	143.2	85.8	227	194.7	116.7	287	246.2	147.5
48	41.2	24.7	108	92.6	55.5	168	144.1	86.4	228	195.6	117.2	288	247.0	148.1
49	42.0	25.2	109	93.5	56.0	169	145.0	86.9	229	196.4	117.7	289	247.9	148.6
50	42.9	25.7	110	94.3	56.5	170	145.8	87.4	230	197.3	118.2	290	248.7	149.1
51	43.7	26.2	111	95.2	57.1	171	146.7	87.9	231	198.1	118.8	291	249.6	149.6
52	44.6	26.7	112	96.1	57.6	172	147.5	88.4	232	199.0	119.3	292	250.5	150.1
53	45.5	27.2	113	96.9	58.1	173	148.4	88.9	233	199.8	119.8	293	251.3	150.6
54	46.3	27.8	114	97.8	58.6	174	149.2	89.4	234	200.7	120.3	294	252.2	151.1
55	47.2	28.3	115	98.6	59.1	175	150.1	90.0	235	201.6	120.8	295	253.0	151.7
56	48.0	28.8	116	99.5	59.6	176	151.0	90.5	236	202.4	121.3	296	253.9	152.2
57	48.9	29.3	117	100.4	60.1	177	151.8	91.0	237	203.3	121.8	297	254.7	152.7
58	49.7	29.8	118	101.2	60.7	178	152.7	91.5	238	204.1	122.4	298	255.6	153.2
59	50.6	30.3	119	102.1	61.2	179	153.5	92.0	239	205.0	122.9	299	256.5	153.7
60	51.5	30.8	120	102.9	61.7	180	154.4	92.5	240	205.9	123.4	300	257.3	154.2
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

for 5 $\frac{1}{4}$ Points.

Difference of Latitude and Departure for 3 Points.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.8	00.6	61	50.7	33.9	121	100.6	67.2	181	150.5	100.6	241	200.4	133.9
2	01.7	01.1	62	51.5	34.4	122	101.4	67.8	182	151.3	101.1	242	201.2	134.4
3	02.5	01.7	63	52.4	35.0	123	102.3	68.3	183	152.2	101.7	243	202.0	135.0
4	03.3	02.2	64	53.2	35.6	124	103.1	68.9	184	153.0	102.2	244	202.9	135.6
5	04.2	02.8	65	54.0	36.1	125	103.9	69.4	185	153.8	102.8	245	203.7	136.1
6	05.0	03.3	66	54.9	36.7	126	104.8	70.0	186	154.6	103.3	246	204.5	136.7
7	05.8	03.9	67	55.7	37.2	127	105.6	70.6	187	155.5	103.9	247	205.4	137.2
8	06.7	04.4	68	56.5	37.8	128	106.4	71.1	188	156.3	104.4	248	206.2	137.8
9	07.5	05.0	69	57.4	38.3	129	107.3	71.7	189	157.1	105.0	249	207.0	138.3
10	08.3	05.6	70	58.2	38.9	130	108.1	72.2	190	158.0	105.6	250	207.9	138.9
11	09.1	06.1	71	59.0	39.4	131	108.9	72.8	191	158.8	106.1	251	208.7	139.4
12	10.0	06.7	72	59.9	40.0	132	109.7	73.3	192	159.6	106.7	252	209.5	140.0
13	10.8	07.2	73	60.7	40.6	133	110.6	73.9	193	160.5	107.2	253	210.4	140.6
14	11.6	07.8	74	61.5	41.1	134	111.4	74.4	194	161.3	107.8	254	211.2	141.1
15	12.5	08.3	75	62.4	41.7	135	112.2	75.0	195	162.1	108.3	255	212.0	141.7
16	13.3	08.9	76	63.2	42.2	136	113.1	75.6	196	163.0	108.9	256	212.9	142.2
17	14.1	09.4	77	64.0	42.8	137	113.9	76.1	197	163.8	109.4	257	213.7	142.8
18	15.0	10.0	78	64.8	43.3	138	114.7	76.7	198	164.6	110.0	258	214.5	143.3
19	15.8	10.6	79	65.7	43.9	139	115.6	77.2	199	165.5	110.6	259	215.3	143.9
20	16.6	11.1	80	66.5	44.4	140	116.4	77.8	200	166.3	111.1	260	216.2	144.4
21	17.5	11.7	81	67.3	45.0	141	117.2	78.3	201	167.1	111.7	261	217.0	145.0
22	18.3	12.2	82	68.2	45.6	142	118.1	78.9	202	168.0	112.2	262	217.8	145.6
23	19.1	12.8	83	69.0	46.1	143	118.9	79.4	203	168.8	112.8	263	218.7	146.1
24	20.0	13.3	84	69.8	46.7	144	119.7	80.0	204	169.6	113.3	264	219.5	146.7
25	20.8	13.9	85	70.7	47.2	145	120.6	80.6	205	170.4	113.9	265	220.3	147.2
26	21.6	14.4	86	71.5	47.8	146	121.4	81.1	206	171.3	114.4	266	221.2	147.8
27	22.4	15.0	87	72.3	48.3	147	122.2	81.7	207	172.1	115.0	267	222.0	148.3
28	23.3	15.6	88	73.2	48.9	148	123.1	82.2	208	172.9	115.6	268	222.8	148.9
29	24.1	16.1	89	74.0	49.4	149	123.9	82.8	209	173.8	116.1	269	223.7	149.4
30	24.9	16.7	90	74.8	50.0	150	124.7	83.3	210	174.6	116.7	270	224.5	150.0
31	25.8	17.2	91	75.7	50.6	151	125.5	83.9	211	175.4	117.2	271	225.3	150.6
32	26.6	17.8	92	76.5	51.1	152	126.4	84.4	212	176.3	117.8	272	226.2	151.1
33	27.4	18.3	93	77.3	51.7	153	127.2	85.0	213	177.1	118.3	273	227.0	151.7
34	28.3	18.9	94	78.2	52.2	154	128.0	85.6	214	177.9	118.9	274	227.8	152.2
35	29.1	19.4	95	79.0	52.8	155	128.9	86.1	215	178.8	119.4	275	228.6	152.8
36	29.9	20.0	96	79.8	53.3	156	129.7	86.7	216	179.6	120.0	276	229.5	153.3
37	30.8	20.6	97	80.6	53.9	157	130.5	87.2	217	180.4	120.6	277	230.3	153.9
38	31.6	21.1	98	81.5	54.4	158	131.4	87.8	218	181.3	121.1	278	231.1	154.4
39	32.4	21.7	99	82.3	55.0	159	132.2	88.3	219	182.1	121.7	279	232.0	155.0
40	33.3	22.2	100	83.1	55.6	160	133.0	88.9	220	182.9	122.2	280	232.8	155.6
41	34.1	22.8	101	84.0	56.1	161	133.9	89.4	221	183.7	122.8	281	233.6	156.1
42	34.9	23.3	102	84.8	56.7	162	134.7	90.0	222	184.6	123.3	282	234.5	156.7
43	35.8	23.9	103	85.6	57.2	163	135.5	90.6	223	185.4	123.9	283	235.3	157.2
44	36.6	24.4	104	86.5	57.8	164	136.4	91.1	224	186.2	124.4	284	236.1	157.8
45	37.4	25.0	105	87.3	58.3	165	137.2	91.7	225	187.1	125.0	285	237.0	158.3
46	38.2	25.6	106	88.1	58.9	166	138.0	92.2	226	187.9	125.6	286	237.8	158.9
47	39.1	26.1	107	89.0	59.4	167	138.9	92.8	227	188.7	126.1	287	238.6	159.4
48	39.9	26.7	108	89.8	60.0	168	139.7	93.3	228	189.6	126.7	288	239.5	160.0
49	40.7	27.2	109	90.6	60.6	169	140.5	93.9	229	190.4	127.2	289	240.3	160.6
50	41.6	27.8	110	91.5	61.1	170	141.3	94.4	230	191.2	127.8	290	241.1	161.1
51	42.4	28.3	111	92.3	61.7	171	142.2	95.0	231	192.1	128.3	291	242.0	161.7
52	43.2	28.9	112	93.1	62.2	172	143.0	95.6	232	192.9	128.9	292	242.8	162.2
53	44.1	29.4	113	94.0	62.8	173	143.8	96.1	233	193.7	129.4	293	243.6	162.8
54	44.9	30.0	114	94.8	63.3	174	144.7	96.7	234	194.6	130.0	294	244.4	163.3
55	45.7	30.6	115	95.6	63.9	175	145.5	97.2	235	195.4	130.6	295	245.3	163.9
56	46.6	31.1	116	96.4	64.4	176	146.3	97.8	236	196.2	131.1	296	246.1	164.4
57	47.4	31.7	117	97.3	65.0	177	147.2	98.3	237	197.1	131.7	297	246.9	165.0
58	48.2	32.2	118	98.1	65.6	178	148.0	98.9	238	197.9	132.2	298	247.8	165.6
59	49.1	32.8	119	98.9	66.1	179	148.8	99.4	239	198.7	132.8	299	248.6	166.1
60	49.9	33.3	120	99.8	66.7	180	149.7	100.0	240	199.5	133.3	300	249.4	166.7
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

for 5 Points.

Difference of Latitude and Departure for 3 ¼ Points.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.8	00.6	61	49.0	36.3	121	97.2	72.1	181	145.4	107.8	241	193.6	143.6
2	01.6	01.2	62	49.8	36.9	122	98.0	72.7	182	146.2	108.4	242	194.4	144.2
3	02.4	01.8	63	50.6	37.5	123	98.8	73.3	183	147.0	109.0	243	195.2	144.8
4	03.2	02.4	64	51.4	38.1	124	99.6	73.9	184	147.8	109.6	244	196.0	145.4
5	04.0	03.0	65	52.2	38.7	125	100.4	74.5	185	148.6	110.2	245	196.8	146.0
6	04.8	03.6	66	53.0	39.3	126	101.2	75.1	186	149.4	110.8	246	197.6	146.5
7	05.6	04.2	67	53.8	39.9	127	102.0	75.7	187	150.2	111.4	247	198.4	147.1
8	06.4	04.8	68	54.6	40.5	128	102.8	76.3	188	151.0	112.0	248	199.2	147.7
9	07.2	05.4	69	55.4	41.1	129	103.6	76.9	189	151.8	112.6	249	200.0	148.3
10	08.0	06.0	70	56.2	41.7	130	104.4	77.4	190	152.6	113.2	250	200.8	148.9
11	08.8	06.6	71	57.0	42.3	131	105.2	78.0	191	153.4	113.8	251	201.6	149.5
12	09.6	07.1	72	57.8	42.9	132	106.0	78.6	192	154.2	114.4	252	202.4	150.1
13	10.4	07.7	73	58.6	43.5	133	106.8	79.2	193	155.0	115.0	253	203.2	150.7
14	11.2	08.3	74	59.4	44.1	134	107.6	79.8	194	155.8	115.6	254	204.0	151.3
15	12.0	08.9	75	60.2	44.7	135	108.4	80.4	195	156.6	116.2	255	204.8	151.9
16	12.8	09.5	76	61.0	45.3	136	109.2	81.0	196	157.4	116.8	256	205.6	152.5
17	13.7	10.1	77	61.8	45.9	137	110.0	81.6	197	158.2	117.4	257	206.4	153.1
18	14.5	10.7	78	62.6	46.5	138	110.8	82.2	198	159.0	118.0	258	207.2	153.7
19	15.3	11.3	79	63.4	47.1	139	111.6	82.8	199	159.8	118.5	259	208.0	154.3
20	16.1	11.9	80	64.3	47.7	140	112.4	83.4	200	160.6	119.1	260	208.8	154.9
21	16.9	12.5	81	65.1	48.3	141	113.2	84.0	201	161.4	119.7	261	209.6	155.5
22	17.7	13.1	82	65.9	48.9	142	114.0	84.6	202	162.2	120.3	262	210.4	156.1
23	18.5	13.7	83	66.7	49.4	143	114.9	85.2	203	163.0	120.9	263	211.2	156.7
24	19.3	14.3	84	67.5	50.0	144	115.7	85.8	204	163.9	121.5	264	212.0	157.3
25	20.1	14.9	85	68.3	50.6	145	116.5	86.4	205	164.7	122.1	265	212.8	157.9
26	20.9	15.5	86	69.1	51.2	146	117.3	87.0	206	165.5	122.7	266	213.6	158.5
27	21.7	16.1	87	69.9	51.8	147	118.1	87.6	207	166.3	123.3	267	214.5	159.1
28	22.5	16.7	88	70.7	52.4	148	118.9	88.2	208	167.1	123.9	268	215.3	159.6
29	23.3	17.3	89	71.5	53.0	149	119.7	88.8	209	167.9	124.5	269	216.1	160.2
30	24.1	17.9	90	72.3	53.6	150	120.5	89.4	210	168.7	125.1	270	216.9	160.8
31	24.9	18.5	91	73.1	54.2	151	121.3	90.0	211	169.5	125.7	271	217.7	161.4
32	25.7	19.1	92	73.9	54.8	152	122.1	90.5	212	170.3	126.3	272	218.5	162.0
33	26.5	19.7	93	74.7	55.4	153	122.9	91.1	213	171.1	126.9	273	219.3	162.6
34	27.3	20.3	94	75.5	56.0	154	123.7	91.7	214	171.9	127.5	274	220.1	163.2
35	28.1	20.9	95	76.3	56.6	155	124.5	92.3	215	172.7	128.1	275	220.9	163.8
36	28.9	21.4	96	77.1	57.2	156	125.3	92.9	216	173.5	128.7	276	221.7	164.4
37	29.7	22.0	97	77.9	57.8	157	126.1	93.5	217	174.3	129.3	277	222.5	165.0
38	30.5	22.6	98	78.7	58.4	158	126.9	94.1	218	175.1	129.9	278	223.3	165.6
39	31.3	23.2	99	79.5	59.0	159	127.7	94.7	219	175.9	130.5	279	224.1	166.2
40	32.1	23.8	100	80.3	59.6	160	128.5	95.3	220	176.7	131.1	280	224.9	166.8
41	32.9	24.4	101	81.1	60.2	161	129.3	95.9	221	177.5	131.7	281	225.7	167.4
42	33.7	25.0	102	81.9	60.8	162	130.1	96.5	222	178.3	132.2	282	226.5	168.0
43	34.5	25.6	103	82.7	61.4	163	130.9	97.1	223	179.1	132.8	283	227.3	168.6
44	35.3	26.2	104	83.5	62.0	164	131.7	97.7	224	179.9	133.4	284	228.1	169.2
45	36.1	26.8	105	84.3	62.6	165	132.5	98.3	225	180.7	134.0	285	228.9	169.8
46	36.9	27.4	106	85.1	63.1	166	133.3	98.9	226	181.5	134.6	286	229.7	170.4
47	37.7	28.0	107	85.9	63.7	167	134.1	99.5	227	182.3	135.2	287	230.5	171.0
48	38.6	28.6	108	86.7	64.3	168	134.9	100.1	228	183.1	135.8	288	231.3	171.6
49	39.4	29.2	109	87.5	64.9	169	135.7	100.7	229	183.9	136.4	289	232.1	172.2
50	40.2	29.8	110	88.4	65.5	170	136.5	101.3	230	184.7	137.0	290	232.9	172.8
51	41.0	30.4	111	89.2	66.1	171	137.3	101.9	231	185.5	137.6	291	233.7	173.3
52	41.8	31.0	112	90.0	66.7	172	138.1	102.5	232	186.3	138.2	292	234.5	173.9
53	42.6	31.6	113	90.8	67.3	173	138.9	103.1	233	187.1	138.8	293	235.3	174.5
54	43.4	32.2	114	91.6	67.9	174	139.8	103.7	234	187.9	139.4	294	236.1	175.1
55	44.2	32.8	115	92.4	68.5	175	140.6	104.2	235	188.8	140.0	295	236.9	175.7
56	45.0	33.4	116	93.2	69.1	176	141.4	104.8	236	189.6	140.6	296	237.7	176.3
57	45.8	34.0	117	94.0	69.7	177	142.2	105.4	237	190.4	141.2	297	238.5	176.9
58	46.6	34.6	118	94.8	70.3	178	143.0	106.0	238	191.2	141.8	298	239.4	177.5
59	47.4	35.1	119	95.6	70.9	179	143.8	106.6	239	192.0	142.4	299	240.2	178.1
60	48.2	35.7	120	96.4	71.5	180	144.6	107.2	240	192.8	143.0	300	241.0	178.7
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Difference of Latitude and Departure for 3 ½ Points.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.8	00.6	61	47.1	38.7	121	93.5	76.8	181	139.9	114.8	241	186.3	152.9
2	01.5	01.3	62	47.9	39.3	122	94.3	77.4	182	140.7	115.5	242	187.1	153.5
3	02.3	01.9	63	48.7	40.0	123	95.1	78.0	183	141.5	116.1	243	187.8	154.2
4	03.1	02.5	64	49.5	40.6	124	95.8	78.7	184	142.2	116.7	244	188.6	154.8
5	03.9	03.2	65	50.2	41.2	125	96.6	79.3	185	143.0	117.4	245	189.4	155.4
6	04.6	03.8	66	51.0	41.9	126	97.4	79.9	186	143.8	118.0	246	190.2	156.1
7	05.4	04.4	67	51.8	42.5	127	98.2	80.6	187	144.5	118.6	247	190.9	156.7
8	06.2	05.1	68	52.6	43.1	128	98.9	81.2	188	145.3	119.3	248	191.7	157.3
9	07.0	05.7	69	53.3	43.8	129	99.7	81.8	189	146.1	119.9	249	192.5	158.0
10	07.7	06.3	70	54.1	44.4	130	100.5	82.5	190	146.9	120.5	250	193.2	158.6
11	08.5	07.0	71	54.9	45.0	131	101.3	83.1	191	147.6	121.2	251	194.0	159.2
12	09.3	07.6	72	55.7	45.7	132	102.0	83.7	192	148.4	121.8	252	194.8	159.9
13	10.1	08.2	73	56.4	46.3	133	102.8	84.4	193	149.2	122.4	253	195.6	160.5
14	10.8	08.9	74	57.2	46.9	134	103.6	85.0	194	150.0	123.1	254	196.3	161.1
15	11.6	09.5	75	58.0	47.6	135	104.4	85.6	195	150.7	123.7	255	197.1	161.8
16	12.4	10.1	76	58.7	48.2	136	105.1	86.3	196	151.5	124.3	256	197.9	162.4
17	13.1	10.8	77	59.5	48.8	137	105.9	86.9	197	152.3	125.0	257	198.7	163.0
18	13.9	11.4	78	60.3	49.5	138	106.7	87.5	198	153.1	125.6	258	199.4	163.7
19	14.7	12.0	79	61.1	50.1	139	107.4	88.2	199	153.8	126.2	259	200.2	164.3
20	15.5	12.7	80	61.8	50.7	140	108.2	88.8	200	154.6	126.9	260	201.0	164.9
21	16.2	13.3	81	62.6	51.4	141	109.0	89.4	201	155.4	127.5	261	201.8	165.6
22	17.0	14.0	82	63.4	52.0	142	109.8	90.1	202	156.1	128.1	262	202.5	166.2
23	17.8	14.6	83	64.2	52.7	143	110.5	90.7	203	156.9	128.8	263	203.3	166.8
24	18.5	15.2	84	64.9	53.3	144	111.3	91.3	204	157.7	129.4	264	204.1	167.5
25	19.3	15.9	85	65.7	53.9	145	112.1	92.0	205	158.5	130.0	265	204.8	168.1
26	20.1	16.5	86	66.5	54.6	146	112.9	92.6	206	159.2	130.7	266	205.6	168.7
27	20.9	17.1	87	67.2	55.2	147	113.6	93.3	207	160.0	131.3	267	206.4	169.4
28	21.6	17.8	88	68.0	55.8	148	114.4	93.9	208	160.8	132.0	268	207.2	170.0
29	22.4	18.4	89	68.8	56.5	149	115.2	94.5	209	161.6	132.6	269	207.9	170.6
30	23.2	19.0	90	69.6	57.1	150	115.9	95.2	210	162.3	133.2	270	208.7	171.3
31	24.0	19.7	91	70.3	57.7	151	116.7	95.8	211	163.1	133.9	271	209.5	171.9
32	24.7	20.3	92	71.1	58.4	152	117.5	96.4	212	163.9	134.5	272	210.3	172.6
33	25.5	20.9	93	71.9	59.0	153	118.3	97.1	213	164.6	135.1	273	211.0	173.2
34	26.3	21.6	94	72.7	59.6	154	119.0	97.7	214	165.4	135.8	274	211.8	173.8
35	27.1	22.2	95	73.4	60.3	155	119.8	98.3	215	166.2	136.4	275	212.6	174.5
36	27.8	22.8	96	74.2	60.9	156	120.6	99.0	216	167.0	137.0	276	213.3	175.1
37	28.6	23.5	97	75.0	61.5	157	121.4	99.6	217	167.7	137.7	277	214.1	175.7
38	29.4	24.1	98	75.7	62.2	158	122.1	100.2	218	168.5	138.3	278	214.9	176.4
39	30.1	24.7	99	76.5	62.8	159	122.9	100.9	219	169.3	138.9	279	215.7	177.0
40	30.9	25.4	100	77.3	63.4	160	123.7	101.5	220	170.1	139.6	280	216.4	177.6
41	31.7	26.0	101	78.1	64.1	161	124.4	102.1	221	170.8	140.2	281	217.2	178.3
42	32.5	26.6	102	78.8	64.7	162	125.2	102.8	222	171.6	140.8	282	218.0	178.9
43	33.2	27.3	103	79.6	65.3	163	126.0	103.4	223	172.4	141.5	283	218.8	179.5
44	34.0	27.9	104	80.4	66.0	164	126.8	104.0	224	173.1	142.1	284	219.5	180.2
45	34.8	28.5	105	81.2	66.6	165	127.5	104.7	225	173.9	142.7	285	220.3	180.8
46	35.6	29.2	106	81.9	67.2	166	128.3	105.3	226	174.7	143.4	286	221.1	181.4
47	36.3	29.8	107	82.7	67.9	167	129.1	105.9	227	175.5	144.0	287	221.8	182.1
48	37.1	30.4	108	83.5	68.5	168	129.9	106.6	228	176.2	144.6	288	222.6	182.7
49	37.9	31.1	109	84.3	69.1	169	130.6	107.2	229	177.0	145.3	289	223.4	183.3
50	38.6	31.7	110	85.0	69.8	170	131.4	107.8	230	177.8	145.9	290	224.2	184.0
51	39.4	32.3	111	85.8	70.4	171	132.2	108.5	231	178.6	146.5	291	224.9	184.6
52	40.2	33.0	112	86.6	71.0	172	133.0	109.1	232	179.3	147.2	292	225.7	185.2
53	41.0	33.6	113	87.3	71.7	173	133.7	109.7	233	180.1	147.8	293	226.5	185.9
54	41.7	34.3	114	88.1	72.3	174	134.5	110.4	234	180.9	148.4	294	227.3	186.5
55	42.5	34.9	115	88.9	73.0	175	135.3	111.0	235	181.7	149.1	295	228.0	187.1
56	43.3	35.5	116	89.7	73.6	176	136.0	111.6	236	182.4	149.7	296	228.8	187.8
57	44.1	36.2	117	90.4	74.2	177	136.8	112.3	237	183.2	150.3	297	229.6	188.4
58	44.8	36.8	118	91.2	74.9	178	137.6	112.9	238	184.0	151.0	298	230.4	189.0
59	45.6	37.4	119	92.0	75.5	179	138.4	113.6	239	184.7	151.6	299	231.1	189.7
60	46.4	38.1	120	92.8	76.1	180	139.1	114.2	240	185.5	152.3	300	231.9	190.3
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

for 4 ½ Points.

Difference of Latitude and Departure for 3 ¾ Points.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.7	00.7	61	45.2	41.0	121	89.6	81.3	181	134.1	121.5	241	178.6	161.8
2	01.5	01.3	62	45.9	41.6	122	90.4	81.9	182	134.8	122.2	242	179.3	162.5
3	02.2	02.0	63	46.7	42.3	123	91.1	82.6	183	135.6	122.9	243	180.0	163.2
4	03.0	02.7	64	47.4	43.0	124	91.9	83.3	184	136.3	123.6	244	180.8	163.8
5	03.7	03.4	65	48.2	43.6	125	92.6	83.9	185	137.1	124.2	245	181.5	164.5
6	04.4	04.0	66	48.9	44.3	126	93.4	84.6	186	137.8	124.9	246	182.3	165.2
7	05.2	04.7	67	49.6	45.0	127	94.1	85.3	187	138.6	125.6	247	183.0	165.9
8	05.9	05.4	68	50.4	45.7	128	94.8	86.0	188	139.3	126.2	248	183.8	166.5
9	06.7	06.0	69	51.1	46.3	129	95.6	86.6	189	140.0	126.9	249	184.5	167.2
10	07.4	06.7	70	51.9	47.0	130	96.3	87.3	190	140.8	127.6	250	185.2	167.9
11	08.2	07.4	71	52.6	47.7	131	97.1	88.0	191	141.5	128.3	251	186.0	168.5
12	08.9	08.1	72	53.3	48.3	132	97.8	88.6	192	142.3	128.9	252	186.7	169.2
13	09.6	08.7	73	54.1	49.0	133	98.5	89.3	193	143.0	129.6	253	187.5	169.9
14	10.4	09.4	74	54.8	49.7	134	99.3	90.0	194	143.7	130.3	254	188.2	170.6
15	11.1	10.1	75	55.6	50.4	135	100.0	90.7	195	144.5	130.9	255	188.9	171.2
16	11.9	10.7	76	56.3	51.0	136	100.8	91.3	196	145.2	131.6	256	189.7	171.9
17	12.6	11.4	77	57.0	51.7	137	101.5	92.0	197	146.0	132.3	257	190.4	172.6
18	13.3	12.1	78	57.8	52.4	138	102.2	92.7	198	146.7	133.0	258	191.2	173.2
19	14.1	12.8	79	58.5	53.0	139	103.0	93.3	199	147.4	133.6	259	191.9	173.9
20	14.8	13.4	80	59.3	53.7	140	103.7	94.0	200	148.2	134.3	260	192.6	174.6
21	15.6	14.1	81	60.0	54.4	141	104.5	94.7	201	148.9	135.0	261	193.4	175.3
22	16.3	14.8	82	60.8	55.1	142	105.2	95.4	202	149.7	135.6	262	194.1	175.9
23	17.0	15.4	83	61.5	55.7	143	106.0	96.0	203	150.4	136.3	263	194.9	176.6
24	17.8	16.1	84	62.2	56.4	144	106.7	96.7	204	151.1	137.0	264	195.6	177.3
25	18.5	16.8	85	63.0	57.1	145	107.4	97.4	205	151.9	137.7	265	196.3	178.0
26	19.3	17.5	86	63.7	57.7	146	108.2	98.0	206	152.6	138.3	266	197.1	178.6
27	20.0	18.1	87	64.5	58.4	147	108.9	98.7	207	153.4	139.0	267	197.8	179.3
28	20.7	18.8	88	65.2	59.1	148	109.7	99.4	208	154.1	139.7	268	198.6	180.0
29	21.5	19.5	89	65.9	59.8	149	110.4	100.1	209	154.9	140.3	269	199.3	180.6
30	22.2	20.1	90	66.7	60.4	150	111.1	100.7	210	155.6	141.0	270	200.1	181.3
31	23.0	20.8	91	67.4	61.1	151	111.9	101.4	211	156.3	141.7	271	200.8	182.0
32	23.7	21.5	92	68.2	61.8	152	112.6	102.1	212	157.1	142.4	272	201.5	182.7
33	24.4	22.2	93	68.9	62.4	153	113.4	102.7	213	157.8	143.0	273	202.3	183.3
34	25.2	22.8	94	69.6	63.1	154	114.1	103.4	214	158.6	143.7	274	203.0	184.0
35	25.9	23.5	95	70.4	63.8	155	114.8	104.1	215	159.3	144.4	275	203.8	184.7
36	26.7	24.2	96	71.1	64.5	156	115.6	104.8	216	160.0	145.0	276	204.5	185.3
37	27.4	24.8	97	71.9	65.1	157	116.3	105.4	217	160.8	145.7	277	205.2	186.0
38	28.2	25.5	98	72.6	65.8	158	117.1	106.1	218	161.5	146.4	278	206.0	186.7
39	28.9	26.2	99	73.3	66.5	159	117.8	106.8	219	162.3	147.1	279	206.7	187.4
40	29.6	26.9	100	74.1	67.2	160	118.5	107.4	220	163.0	147.7	280	207.5	188.0
41	30.4	27.5	101	74.8	67.8	161	119.3	108.1	221	163.7	148.4	281	208.2	188.7
42	31.1	28.2	102	75.6	68.5	162	120.0	108.8	222	164.5	149.1	282	208.9	189.4
43	31.9	28.9	103	76.3	69.2	163	120.8	109.5	223	165.2	149.7	283	209.7	190.0
44	32.6	29.5	104	77.1	69.8	164	121.5	110.1	224	166.0	150.4	284	210.4	190.7
45	33.3	30.2	105	77.8	70.5	165	122.3	110.8	225	166.7	151.1	285	211.2	191.4
46	34.1	30.9	106	78.5	71.2	166	123.0	111.5	226	167.4	151.8	286	211.9	192.1
47	34.8	31.6	107	79.3	71.8	167	123.7	112.1	227	168.2	152.4	287	212.6	192.7
48	35.6	32.2	108	80.0	72.5	168	124.5	112.8	228	168.9	153.1	288	213.4	193.4
49	36.3	32.9	109	80.8	73.2	169	125.2	113.5	229	169.7	153.8	289	214.1	194.1
50	37.0	33.6	110	81.5	73.9	170	126.0	114.2	230	170.4	154.5	290	214.9	194.7
51	37.8	34.2	111	82.2	74.5	171	126.7	114.8	231	171.2	155.1	291	215.6	195.4
52	38.5	34.9	112	83.0	75.2	172	127.4	115.5	232	171.9	155.8	292	216.4	196.1
53	39.3	35.6	113	83.7	75.9	173	128.2	116.2	233	172.6	156.5	293	217.1	196.8
54	40.0	36.3	114	84.5	76.5	174	128.9	116.8	234	173.4	157.1	294	217.8	197.4
55	40.7	36.9	115	85.2	77.2	175	129.7	117.5	235	174.1	157.8	295	218.6	198.1
56	41.5	37.6	116	85.9	77.9	176	130.4	118.2	236	174.9	158.5	296	219.3	198.8
57	42.2	38.3	117	86.7	78.6	177	131.1	118.9	237	175.6	159.1	297	220.1	199.4
58	43.0	38.9	118	87.4	79.2	178	131.9	119.5	238	176.3	159.8	298	220.8	200.1
59	43.7	39.6	119	88.2	79.9	179	132.6	120.2	239	177.1	160.5	299	221.5	200.8
60	44.5	40.3	120	88.9	80.6	180	133.4	120.9	240	177.8	161.2	300	222.3	201.5
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Difference of Latitude and Departure for 4 Points.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.7	00.7	61	43.1	43.1	121	85.6	85.6	181	128.0	128.0	241	170.4	170.4
2	01.4	01.4	62	43.8	43.8	122	86.3	86.3	182	128.7	128.7	242	171.1	171.1
3	02.1	02.1	63	44.5	44.5	123	87.0	87.0	183	129.4	129.4	243	171.8	171.8
4	02.8	02.8	64	45.3	45.3	124	87.7	87.7	184	130.1	130.1	244	172.5	172.5
5	03.5	03.5	65	46.0	46.0	125	88.4	88.4	185	130.8	130.8	245	173.2	173.2
6	04.2	04.2	66	46.7	46.7	126	89.1	89.1	186	131.5	131.5	246	173.9	173.9
7	04.9	04.9	67	47.4	47.4	127	89.8	89.8	187	132.2	132.2	247	174.7	174.7
8	05.7	05.7	68	48.1	48.1	128	90.5	90.5	188	132.9	132.9	248	175.4	175.4
9	06.4	06.4	69	48.8	48.8	129	91.2	91.2	189	133.6	133.6	249	176.1	176.1
10	07.1	07.1	70	49.5	49.5	130	91.9	91.9	190	134.3	134.3	250	176.8	176.8
11	07.8	07.8	71	50.2	50.2	131	92.6	92.6	191	135.1	135.1	251	177.5	177.5
12	08.5	08.5	72	50.9	50.9	132	93.3	93.3	192	135.8	135.8	252	178.2	178.2
13	09.2	09.2	73	51.6	51.6	133	94.0	94.0	193	136.5	136.5	253	178.9	178.9
14	09.9	09.9	74	52.3	52.3	134	94.8	94.8	194	137.2	137.2	254	179.6	179.6
15	10.6	10.6	75	53.0	53.0	135	95.5	95.5	195	137.9	137.9	255	180.3	180.3
16	11.3	11.3	76	53.7	53.7	136	96.2	96.2	196	138.6	138.6	256	181.0	181.0
17	12.0	12.0	77	54.4	54.4	137	96.9	96.9	197	139.3	139.3	257	181.7	181.7
18	12.7	12.7	78	55.2	55.2	138	97.6	97.6	198	140.0	140.0	258	182.4	182.4
19	13.4	13.4	79	55.9	55.9	139	98.3	98.3	199	140.7	140.7	259	183.1	183.1
20	14.1	14.1	80	56.6	56.6	140	99.0	99.0	200	141.4	141.4	260	183.8	183.8
21	14.8	14.8	81	57.3	57.3	141	99.7	99.7	201	142.1	142.1	261	184.6	184.6
22	15.6	15.6	82	58.0	58.0	142	100.4	100.4	202	142.8	142.8	262	185.3	185.3
23	16.3	16.3	83	58.7	58.7	143	101.1	101.1	203	143.5	143.5	263	186.0	186.0
24	17.0	17.0	84	59.4	59.4	144	101.8	101.8	204	144.2	144.2	264	186.7	186.7
25	17.7	17.7	85	60.1	60.1	145	102.5	102.5	205	145.0	145.0	265	187.4	187.4
26	18.4	18.4	86	60.8	60.8	146	103.2	103.2	206	145.7	145.7	266	188.1	188.1
27	19.1	19.1	87	61.5	61.5	147	103.9	103.9	207	146.4	146.4	267	188.8	188.8
28	19.8	19.8	88	62.2	62.2	148	104.7	104.7	208	147.1	147.1	268	189.5	189.5
29	20.5	20.5	89	62.9	62.9	149	105.4	105.4	209	147.8	147.8	269	190.2	190.2
30	21.2	21.2	90	63.6	63.6	150	106.1	106.1	210	148.5	148.5	270	190.9	190.9
31	21.9	21.9	91	64.3	64.3	151	106.8	106.8	211	149.2	149.2	271	191.6	191.6
32	22.6	22.6	92	65.1	65.1	152	107.5	107.5	212	149.9	149.9	272	192.3	192.3
33	23.3	23.3	93	65.8	65.8	153	108.2	108.2	213	150.6	150.6	273	193.0	193.0
34	24.0	24.0	94	66.5	66.5	154	108.9	108.9	214	151.3	151.3	274	193.7	193.7
35	24.7	24.7	95	67.2	67.2	155	109.6	109.6	215	152.0	152.0	275	194.5	194.5
36	25.5	25.5	96	67.9	67.9	156	110.3	110.3	216	152.7	152.7	276	195.2	195.2
37	26.2	26.2	97	68.6	68.6	157	111.0	111.0	217	153.4	153.4	277	195.9	195.9
38	26.9	26.9	98	69.3	69.3	158	111.7	111.7	218	154.1	154.1	278	196.6	196.6
39	27.6	27.6	99	70.0	70.0	159	112.4	112.4	219	154.9	154.9	279	197.3	197.3
40	28.3	28.3	100	70.7	70.7	160	113.1	113.1	220	155.6	155.6	280	198.0	198.0
41	29.0	29.0	101	71.4	71.4	161	113.8	113.8	221	156.3	156.3	281	198.7	198.7
42	29.7	29.7	102	72.1	72.1	162	114.5	114.5	222	157.0	157.0	282	199.4	199.4
43	30.4	30.4	103	72.8	72.8	163	115.3	115.3	223	157.7	157.7	283	200.1	200.1
44	31.1	31.1	104	73.5	73.5	164	116.0	116.0	224	158.4	158.4	284	200.8	200.8
45	31.8	31.8	105	74.2	74.2	165	116.7	116.7	225	159.1	159.1	285	201.5	201.5
46	32.5	32.5	106	75.0	75.0	166	117.4	117.4	226	159.8	159.8	286	202.2	202.2
47	33.2	33.2	107	75.7	75.7	167	118.1	118.1	227	160.5	160.5	287	202.9	202.9
48	33.9	33.9	108	76.4	76.4	168	118.8	118.8	228	161.2	161.2	288	203.6	203.6
49	34.6	34.6	109	77.1	77.1	169	119.5	119.5	229	161.9	161.9	289	204.3	204.3
50	35.4	35.4	110	77.8	77.8	170	120.2	120.2	230	162.6	162.6	290	205.1	205.1
51	36.1	36.1	111	78.5	78.5	171	120.9	120.9	231	163.3	163.3	291	205.8	205.8
52	36.8	36.8	112	79.2	79.2	172	121.6	121.6	232	164.0	164.0	292	206.5	206.5
53	37.5	37.5	113	79.9	79.9	173	122.3	122.3	233	164.8	164.8	293	207.2	207.2
54	38.2	38.2	114	80.6	80.6	174	123.0	123.0	234	165.5	165.5	294	207.9	207.9
55	38.9	38.9	115	81.3	81.3	175	123.7	123.7	235	166.2	166.2	295	208.6	208.6
56	39.6	39.6	116	82.0	82.0	176	124.4	124.4	236	166.9	166.9	296	209.3	209.3
57	40.3	40.3	117	82.7	82.7	177	125.2	125.2	237	167.6	167.6	297	210.0	210.0
58	41.0	41.0	118	83.4	83.4	178	125.9	125.9	238	168.3	168.3	298	210.7	210.7
59	41.7	41.7	119	84.1	84.1	179	126.6	126.6	239	169.0	169.0	299	211.4	211.4
60	42.4	42.4	120	84.8	84.8	180	127.3	127.3	240	169.7	169.7	300	212.1	212.1
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Difference of Latitude and Departure for 1°.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	01.0	00.0	61	61.0	01.1	121	121.0	02.1	181	181.0	03.2	241	241.0	04.2
2	02.0	00.0	62	62.0	01.1	122	122.0	02.1	182	182.0	03.2	242	242.0	04.2
3	03.0	00.1	63	63.0	01.1	123	123.0	02.1	183	183.0	03.2	243	243.0	04.2
4	04.0	00.1	64	64.0	01.1	124	124.0	02.2	184	184.0	03.2	244	244.0	04.3
5	05.0	00.1	65	65.0	01.1	125	125.0	02.2	185	185.0	03.2	245	245.0	04.3
6	06.0	00.1	66	66.0	01.2	126	126.0	02.2	186	186.0	03.2	246	246.0	04.3
7	07.0	00.1	67	67.0	01.2	127	127.0	02.2	187	187.0	03.3	247	247.0	04.3
8	08.0	00.1	68	68.0	01.2	128	128.0	02.2	188	188.0	03.3	248	248.0	04.3
9	09.0	00.2	69	69.0	01.2	129	129.0	02.3	189	189.0	03.3	249	249.0	04.3
10	10.0	00.2	70	70.0	01.2	130	130.0	02.3	190	190.0	03.3	250	250.0	04.4
11	11.0	00.2	71	71.0	01.2	131	131.0	02.3	191	191.0	03.3	251	251.0	04.4
12	12.0	00.2	72	72.0	01.3	132	132.0	02.3	192	192.0	03.4	252	252.0	04.4
13	13.0	00.2	73	73.0	01.3	133	133.0	02.3	193	193.0	03.4	253	253.0	04.4
14	14.0	00.2	74	74.0	01.3	134	134.0	02.3	194	194.0	03.4	254	254.0	04.4
15	15.0	00.3	75	75.0	01.3	135	135.0	02.4	195	195.0	03.4	255	255.0	04.5
16	16.0	00.3	76	76.0	01.3	136	136.0	02.4	196	196.0	03.4	256	256.0	04.5
17	17.0	00.3	77	77.0	01.3	137	137.0	02.4	197	197.0	03.4	257	257.0	04.5
18	18.0	00.3	78	78.0	01.4	138	138.0	02.4	198	198.0	03.5	258	258.0	04.5
19	19.0	00.3	79	79.0	01.4	139	139.0	02.4	199	199.0	03.5	259	259.0	04.5
20	20.0	00.3	80	80.0	01.4	140	140.0	02.4	200	200.0	03.5	260	260.0	04.5
21	21.0	00.4	81	81.0	01.4	141	141.0	02.5	201	201.0	03.5	261	261.0	04.6
22	22.0	00.4	82	82.0	01.4	142	142.0	02.5	202	202.0	03.5	262	262.0	04.6
23	23.0	00.4	83	83.0	01.4	143	143.0	02.5	203	203.0	03.5	263	263.0	04.6
24	24.0	00.4	84	84.0	01.5	144	144.0	02.5	204	204.0	03.6	264	264.0	04.6
25	25.0	00.4	85	85.0	01.5	145	145.0	02.5	205	205.0	03.6	265	265.0	04.6
26	26.0	00.5	86	86.0	01.5	146	146.0	02.5	206	206.0	03.6	266	266.0	04.6
27	27.0	00.5	87	87.0	01.5	147	147.0	02.6	207	207.0	03.6	267	267.0	04.7
28	28.0	00.5	88	88.0	01.5	148	148.0	02.6	208	208.0	03.6	268	268.0	04.7
29	29.0	00.5	89	89.0	01.6	149	149.0	02.6	209	209.0	03.6	269	269.0	04.7
30	30.0	00.5	90	90.0	01.6	150	150.0	02.6	210	210.0	03.7	270	270.0	04.7
31	31.0	00.5	91	91.0	01.6	151	151.0	02.6	211	211.0	03.7	271	271.0	04.7
32	32.0	00.6	92	92.0	01.6	152	152.0	02.7	212	212.0	03.7	272	272.0	04.7
33	33.0	00.6	93	93.0	01.6	153	153.0	02.7	213	213.0	03.7	273	273.0	04.8
34	34.0	00.6	94	94.0	01.6	154	154.0	02.7	214	214.0	03.7	274	274.0	04.8
35	35.0	00.6	95	95.0	01.7	155	155.0	02.7	215	215.0	03.8	275	275.0	04.8
36	36.0	00.6	96	96.0	01.7	156	156.0	02.7	216	216.0	03.8	276	276.0	04.8
37	37.0	00.6	97	97.0	01.7	157	157.0	02.7	217	217.0	03.8	277	277.0	04.8
38	38.0	00.7	98	98.0	01.7	158	158.0	02.8	218	218.0	03.8	278	278.0	04.9
39	39.0	00.7	99	99.0	01.7	159	159.0	02.8	219	219.0	03.8	279	279.0	04.9
40	40.0	00.7	100	100.0	01.7	160	160.0	02.8	220	220.0	03.8	280	280.0	04.9
41	41.0	00.7	101	101.0	01.8	161	161.0	02.8	221	221.0	03.9	281	281.0	04.9
42	42.0	00.7	102	102.0	01.8	162	162.0	02.8	222	222.0	03.9	282	282.0	04.9
43	43.0	00.8	103	103.0	01.8	163	163.0	02.8	223	223.0	03.9	283	283.0	04.9
44	44.0	00.8	104	104.0	01.8	164	164.0	02.9	224	224.0	03.9	284	284.0	05.0
45	45.0	00.8	105	105.0	01.8	165	165.0	02.9	225	225.0	03.9	285	285.0	05.0
46	46.0	00.8	106	106.0	01.8	166	166.0	02.9	226	226.0	03.9	286	286.0	05.0
47	47.0	00.8	107	107.0	01.9	167	167.0	02.9	227	227.0	04.0	287	287.0	05.0
48	48.0	00.8	108	108.0	01.9	168	168.0	02.9	228	228.0	04.0	288	288.0	05.0
49	49.0	00.9	109	109.0	01.9	169	169.0	02.9	229	229.0	04.0	289	289.0	05.0
50	50.0	00.9	110	110.0	01.9	170	170.0	03.0	230	230.0	04.0	290	290.0	05.1
51	51.0	00.9	111	111.0	01.9	171	171.0	03.0	231	231.0	04.0	291	291.0	05.1
52	52.0	00.9	112	112.0	02.0	172	172.0	03.0	232	232.0	04.0	292	292.0	05.1
53	53.0	00.9	113	113.0	02.0	173	173.0	03.0	233	233.0	04.1	293	293.0	05.1
54	54.0	00.9	114	114.0	02.0	174	174.0	03.0	234	234.0	04.1	294	294.0	05.1
55	55.0	01.0	115	115.0	02.0	175	175.0	03.1	235	235.0	04.1	295	295.0	05.1
56	56.0	01.0	116	116.0	02.0	176	176.0	03.1	236	236.0	04.1	296	296.0	05.2
57	57.0	01.0	117	117.0	02.0	177	177.0	03.1	237	237.0	04.1	297	297.0	05.2
58	58.0	01.0	118	118.0	02.1	178	178.0	03.1	238	238.0	04.2	298	298.0	05.2
59	59.0	01.0	119	119.0	02.1	179	179.0	03.1	239	239.0	04.2	299	299.0	05.2
60	60.0	01.0	120	120.0	02.1	180	180.0	03.1	240	240.0	04.2	300	300.0	05.2
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Difference of Latitude and Departure for 2°.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	01.0	00.0	61	61.0	02.1	121	120.9	04.2	181	180.9	06.3	241	240.9	08.4
2	02.0	00.1	62	62.0	02.2	122	121.9	04.3	182	181.9	06.4	242	241.9	08.4
3	03.0	00.1	63	63.0	02.2	123	122.9	04.3	183	182.9	06.4	243	242.9	08.5
4	04.0	00·1	64	64.0	02.2	124	123.9	04.3	184	183.9	06.4	244	243.9	08.5
5	05.0	00.2	65	65.0	02.3	125	124.9	04.4	185	184.9	06.5	245	244.9	08.6
6	06.0	00.2	66	66.0	02.3	126	125.9	04.4	186	185.9	06.5	246	245.9	08.6
7	07.0	00.2	67	67.0	02.3	127	126.9	04.4	187	186.9	06.5	247	246.8	08.6
8	08.0	00.3	68	68.0	02.4	128	127.9	04.5	188	187.9	06.6	248	247.8	08.7
9	09.0	00.3	69	69.0	02.4	129	128.9	04.5	189	188.9	06.6	249	248.8	08.7
10	10.0	00.3	70	70.0	02.4	130	129.9	04.5	190	189.9	06.6	250	249.8	08.7
11	11.0	00.4	71	71.0	02.5	131	130 9	04.6	191	190.9	06.7	251	250.8	08.8
12	12.0	00 4	72	72.0	02.5	132	131.9	04.6	192	191.9	06.7	252	251.8	08.8
13	13.0	00.5	73	73.0	02.5	133	132.9	04.6	193	192.9	06.7	253	252.8	08.8
14	14.0	00.5	74	74.0	02.6	134	133.9	04.7	194	193.9	06.8	254	253.8	08.9
15	15.0	00.5	75	75.0	02.6	135	134.9	04.7	195	194.9	06.8	255	254.8	08.9
16	16.0	00.6	76	76.0	02.7	136	135.9	04.7	196	195.9	06.8	256	255.8	08.9
17	17.0	00.6	77	77.0	02.7	137	136.9	04.8	197	196.9	06.9	257	256.8	09.0
18	18.0	00.6	78	78.0	02.7	138	137.9	04.8	198	197.9	06.9	258	257.8	09.0
19	19.0	00.7	79	79.0	02.8	139	138.9	04.9	199	198.9	06.9	259	258.8	09.0
20	20.0	00.7	80	80.0	02.8	140	139.9	04.9	200	199.9	07.0	260	259.8	09.1
21	21.0	00.7	81	81.0	02.8	141	140.9	04.9	201	200.9	07.0	261	260.8	09.1
22	22.0	00.8	82	82.0	02.9	142	141.9	05.0	202	201.9	07.0	262	261.8	09.1
23	23.0	00.8	83	82.9	02.9	143	142.9	05.0	203	202.9	07.1	263	262.8	09.2
24	24.0	00.8	84	83.9	02.9	144	143.9	05.0	204	203.9	07.1	264	263.8	09.2
25	25.0	00.9	85	84.9	03.0	145	144.9	05.1	205	204.9	07.2	265	264.8	09.2
26	26.0	00.9	86	85.9	03.0	146	145.9	05.1	206	205.9	07.2	266	265.8	09.3
27	27.0	00.9	87	86.9	03·0	147	146 9	05.1	207	206.9	07.2	267	266.8	09.3
28	28.0	01.0	88	87.9	03.1	148	147.9	05.2	208	207.9	07.3	268	267.8	09.4
29	29.0	01.0	89	88.9	03.1	149	148.9	05.2	209	208.9	07.3	269	268.8	09.4
30	30.0	01.0	90	89.9	03.1	150	149.9	05.2	210	209.9	07.3	270	269.8	09.4
31	31.0	01.1	91	90.9	03.2	151	150.9	05.3	211	210.9	07.4	271	270.8	09.5
32	32.0	01.1	92	91.9	03.2	152	151.9	05.3	212	211.9	07.4	272	271.8	09.5
33	33.0	01.2	93	92.9	03.2	153	152.9	05.3	213	212.9	07.4	273	272.8	09.5
34	34.0	01.2	94	93.9	03.3	154	153.9	05.4	214	213.9	07.5	274	273.8	09.6
35	35.0	01.2	95	94.9	03.3	155	154.9	05.4	215	214.9	07.5	275	274.8	09.6
36	36.0	01.3	96	95.9	03.4	156	155.9	05.4	216	215.9	07.5	276	275.8	09.6
37	37.0	01.3	97	96.9	03.4	157	156.9	05.5	217	216.9	07.6	277	276.8	09.7
38	38.0	01.3	98	97.9	03.4	158	157.9	05.5	218	217.9	07.6	278	277.8	09.7
39	39.0	01.4	99	98.9	03.5	159	158.9	05.5	219	218.9	07.6	279	278.8	09.7
40	40.0	01.4	100	99.9	03.5	160	159.9	05.6	220	219.9	07.7	280	279.8	09.8
41	41.0	01.4	101	100.9	03.5	161	160.9	05.6	221	220.9	07.7	281	280.8	09.8
42	42.0	01.5	102	101.9	03.6	162	161.9	05.7	222	221.9	07.7	282	281.8	09.8
43	43.0	01.5	103	102.9	03.6	163	162.9	05.7	223	222.9	07.8	283	282.8	09.9
44	44.0	01.5	104	103.9	03.6	164	163.9	05.7	224	223.9	07.8	284	283.8	09.9
45	45.0	01.6	105	104.9	03.7	165	164.9	05.8	225	224.9	07.9	285	284.8	09.9
46	46.0	01.6	106	105.9	03.7	166	165.9	05.8	226	225.9	07.9	286	285.8	10.0
47	47.0	01.6	107	106.9	03.7	167	166.9	05.8	227	226.9	07.9	287	286.8	10.0
48	48.0	01.7	108	107.9	03.8	168	167.9	05.9	228	227.9	08.0	288	287.8	10.1
49	49.0	01.7	109	108.9	03.8	169	168.9	05.9	229	228.9	08.0	289	288.8	10.1
50	50.0	01.7	110	109.9	03.8	170	169.9	05.9	230	229.9	08.0	290	289.8	10.1
51	51.0	01.8	111	110.9	03.9	171	170.9	06.0	231	230.9	08.1	291	290.8	10.2
52	52.0	01.8	112	111.9	03.9	172	171.9	06.0	232	231.9	08.1	292	291.8	10.2
53	53.0	01.8	113	112.9	03.9	173	172.9	06.0	233	232.9	08.1	293	292.8	10.2
54	54.0	01.9	114	113.9	04.0	174	173.9	06.1	234	233.9	08.2	294	293.8	10.3
55	55.0	01.9	115	114.9	04.0	175	174.9	06.1	235	234.9	08.2	295	294.8	10.3
56	56.0	02.0	116	115.9	04.0	176	175.9	06.1	236	235.9	08.2	296	295.8	10.3
57	57.0	02.0	117	116.9	04.1	177	176.9	06.2	237	236.9	08.3	297	296.8	10.4
58	58.0	02.0	118	117.9	04.1	178	177.9	06.2	238	237.9	08.3	298	297.8	10.4
59	59.0	02.1	119	118.9	04.2	179	178.9	06.2	239	238.9	08.3	299	298.8	10.4
60	60.0	02.1	120	119.9	04.2	180	179.9	06.3	240	239.9	08.4	300	299.8	10.5
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Difference of Latitude and Departure for 3°.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	01.0	00.1	61	60.9	03.2	121	120.8	06.3	181	180.8	09.5	241	240.7	12.6
2	02.0	00.1	62	61.9	03.2	122	121.8	06.4	182	181.8	09.5	242	241.7	12.7
3	03.0	00.2	63	62.9	03.3	123	122.8	06.4	183	182.7	09.6	243	242.7	12.7
4	04.0	00.2	64	63.9	03.3	124	123.8	06.5	184	183.7	09.6	244	243.7	12.8
5	05.0	00.3	65	64.9	03.4	125	124.8	06.5	185	184.7	09.7	245	244.7	12.8
6	06.0	00.3	66	65.9	03.5	126	125.8	06.6	186	185.7	09.7	246	245.7	12.9
7	07.0	00.4	67	66.9	03.5	127	126.8	06.6	187	186.7	09.8	247	246.7	12.9
8	08.0	00.4	68	67.9	03.6	128	127.8	06.7	188	187.7	09.8	248	247.7	13.0
9	09.0	00.5	69	68.9	03.6	129	128.8	06.8	189	188.7	09.9	249	248.7	13.0
10	10.0	00.5	70	69.9	03.7	130	129.8	06.8	190	189.7	09.9	250	249.7	13.1
11	11.0	00.6	71	70.9	03.7	131	130.8	06.9	191	190.7	10.0	251	250.7	13.1
12	12.0	00.6	72	71.9	03.8	132	131.8	06.9	192	191.7	10.0	252	251.7	13.2
13	13.0	00.7	73	72.9	03.8	133	132.8	07.0	193	192.7	10.1	253	252.7	13.2
14	14.0	00.7	74	73.9	03.9	134	133.8	07.0	194	193.7	10.2	254	253.7	13.3
15	15.0	00.8	75	74.9	03.9	135	134.8	07.1	195	194.7	10.2	255	254.7	13.3
16	16.0	00.8	76	75.9	04.0	136	135.8	07.1	196	195.7	10.3	256	255.6	13.4
17	17.0	00.9	77	76.9	04.0	137	136.8	07.2	197	196.7	10.3	257	256.6	13.5
18	18.0	00.9	78	77.9	04.1	138	137.8	07.2	198	197.7	10.4	258	257.6	13.5
19	19.0	01.0	79	78.9	04.1	139	138.8	07.3	199	198.7	10.4	259	258.6	13.6
20	20.0	01.0	80	79.9	04.2	140	139.8	07.3	200	199.7	10.5	260	259.6	13.6
21	21.0	01.1	81	80.9	04.2	141	140.8	07.4	201	200.7	10.5	261	260.6	13.7
22	22.0	01.2	82	81.9	04.3	142	141.8	07.4	202	201.7	10.6	262	261.6	13.7
23	23.0	01.2	83	82.9	04.3	143	142.8	07.5	203	202.7	10.6	263	262.6	13.8
24	24.0	01.3	84	83.9	04.4	144	143.8	07.5	204	203.7	10.7	264	263.5	13.8
25	25.0	01.3	85	84.9	04.4	145	144.8	07.6	205	204.7	10.7	265	264.6	13.9
26	26.0	01.4	86	85.9	04.5	146	145.8	07.6	206	205.7	10.8	266	265.6	13.9
27	27.0	01.4	87	86.9	04.6	147	146.8	07.7	207	206.7	10.8	267	266.6	14.0
28	28.0	01.5	88	87.9	04.6	148	147.8	07.7	208	207.7	10.9	268	267.6	14.0
29	29.0	01.5	89	88.9	04.7	149	148.8	07.8	209	208.7	10.9	269	268.6	14.1
30	30.0	01.6	90	89.9	04.7	150	149.8	07.9	210	209.7	11.0	270	269.6	14.1
31	31.0	01.6	91	90.9	04.8	151	150.8	07.9	211	210.7	11.0	271	270.6	14.2
32	32.0	01.7	92	91.9	04.8	152	151.8	08.0	212	211.7	11.1	272	271.6	14.2
33	33.0	01.7	93	92.9	04.9	153	152.8	08.0	213	212.7	11.1	273	272.6	14.3
34	34.0	01.8	94	93.9	04.9	154	153.8	08.1	214	213.7	11.2	274	273.6	14.3
35	35.0	01.8	95	94.9	05.0	155	154.8	08.1	215	214.7	11.3	275	274.6	14.4
36	36.0	01.9	96	95.9	05.0	156	155.8	08.2	216	215.7	11.3	276	275.6	14.4
37	36.9	01.9	97	96.9	05.1	157	156.8	08.2	217	216.7	11.4	277	276.6	14.5
38	37.9	02.0	98	97.9	05.1	158	157.8	08.3	218	217.7	11.4	278	277.6	14.5
39	38.9	02.0	99	98.9	05.2	159	158.8	08.3	219	218.7	11.5	279	278.6	14.6
40	39.9	02.1	100	99.9	05.2	160	159.8	08.4	220	219.7	11.5	280	279.6	14.7
41	40.9	02.1	101	100.9	05.3	161	160.8	08.4	221	220.7	11.6	281	280.6	14.7
42	41.9	02.2	102	101.9	05.3	162	161.8	08.5	222	221.7	11.6	282	281.6	14.8
43	42.9	02.3	103	102.9	05.4	163	162.8	08.5	223	222.7	11.7	283	282.6	14.8
44	43.9	02.3	104	103.9	05.4	164	163.8	08.6	224	223.7	11.7	284	283.6	14.9
45	44.9	02.4	105	104.9	05.5	165	164.8	08.6	225	224.7	11.8	285	284.6	14.9
46	45.9	02.4	106	105.9	05.5	166	165.8	08.7	226	225.7	11.8	286	285.6	15.0
47	46.9	02.5	107	106.9	05.6	167	166.8	08.7	227	226.7	11.9	287	286.6	15.0
48	47.9	02.5	108	107.9	05.7	168	167.8	08.8	228	227.7	11.9	288	287.6	15.1
49	48.9	02.6	109	108.9	05.7	169	168.8	08.8	229	228.7	12.0	289	288.6	15.1
50	49.9	02.6	110	109.8	05.8	170	169.8	08.9	230	229.7	12.0	290	289.6	15.2
51	50.9	02.7	111	110.8	05.8	171	170.8	08.9	231	230.7	12.1	291	290.6	15.2
52	51.9	02.7	112	111.8	05.9	172	171.8	09.0	232	231.7	12.1	292	291.6	15.3
53	52.9	02.8	113	112.8	05.9	173	172.8	09.1	233	232.7	12.2	293	292.6	15.3
54	53.9	02.8	114	113.8	06.0	174	173.8	09.1	234	233.7	12.2	294	293.6	15.4
55	54.9	02.9	115	114.8	06.0	175	174.8	09.2	235	234.7	12.3	295	294.6	15.4
56	55.9	02.9	116	115.8	06.1	176	175.8	09.2	236	235.7	12.4	296	295.6	15.5
57	56.9	03.0	117	116.8	06.1	177	176.8	09.3	237	236.7	12.4	297	296.6	15.5
58	57.9	03.0	118	117.8	06.2	178	177.8	09.3	238	237.7	12.5	298	297.6	15.6
59	58.9	03.1	119	118.8	06.2	179	178.8	09.4	239	238.7	12.5	299	298.6	15.6
60	59.9	03.1	120	119.8	06.3	180	179.8	09.4	240	239.7	12.6	300	299.6	15.7
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

TABLE II.

Difference of Latitude and Departure for 4°.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	01.0	00.1	61	60.9	04.3	121	120.7	08.4	181	180.6	12.6	241	240.4	16.8
2	02.0	00.1	62	61.8	04.3	122	121.7	08.5	182	181.6	12.7	242	241.4	16.9
3	03.0	00.2	63	62.8	04.4	123	122.7	08.6	183	182.6	12.8	243	242.4	17.0
4	04.0	00.3	64	63.8	04.5	124	123.7	08.6	184	183.6	12.8	244	243.4	17.0
5	05.0	00.3	65	64.8	04.5	125	124.7	08.7	185	184.5	12.9	245	244.4	17.1
6	06.0	00.4	66	65.8	04.6	126	125.7	08.8	186	185.5	13.0	246	245.4	17.2
7	07.0	00.5	67	66.8	04.7	127	126.7	08.9	187	186.5	13.0	247	246.4	17.2
8	08.0	00.6	68	67.8	04.7	128	127.7	08.9	188	187.5	13.1	248	247.4	17.3
9	09.0	00.6	69	68.8	04.8	129	128.7	09.0	189	188.5	13.2	249	248.4	17.4
10	10.0	00.7	70	69.8	04.9	130	129.7	09.1	190	189.5	13.3	250	249.4	17.4
11	11.0	00.8	71	70.8	05.0	131	130.7	09.1	191	190.5	13.3	251	250.4	17.5
12	12.0	00.8	72	71.8	05.0	132	131.7	09.2	192	191.5	13.4	252	251.4	17.6
13	13.0	00.9	73	72.8	05.1	133	132.7	09.3	193	192.5	13.5	253	252.4	17.6
14	14.0	01.0	74	73.8	05.2	134	133.7	09.3	194	193.5	13.5	254	253.4	17.7
15	15.0	01.0	75	74.8	05.2	135	134.7	09.4	195	194.5	13.6	255	254.4	17.8
16	16.0	01.1	76	75.8	05.3	136	135.7	09.5	196	195.5	13.7	256	255.4	17.9
17	17.0	01.2	77	76.8	05.4	137	136.7	09.6	197	196.5	13.7	257	256.4	17.9
18	18.0	01.3	78	77.8	05.4	138	137.7	09.6	198	197.5	13.8	258	257.4	18.0
19	19.0	01.3	79	78.8	05.5	139	138.7	09.7	199	198.5	13.9	259	258.4	18.1
20	20.0	01.4	80	79.8	05.6	140	139.7	09.8	200	199.5	14.0	260	259.4	18.1
21	20.9	01.5	81	80.8	05.7	141	140.7	09.8	201	200.5	14.0	261	260.4	18.2
22	21.9	01.5	82	81.8	05.7	142	141.7	09.9	202	201.5	14.1	262	261.4	18.3
23	22.9	01.6	83	82.8	05.8	143	142.7	10.0	203	202.5	14.2	263	262.4	18.3
24	23.9	01.7	84	83.8	05.9	144	143.6	10.0	204	203.5	14.2	264	263.4	18.4
25	24.9	01.7	85	84.8	05.9	145	144.6	10.1	205	204.5	14.3	265	264.4	18.5
26	25.9	01.8	86	85.8	06.0	146	145.6	10.2	206	205.5	14.4	266	265.4	18.6
27	26.9	01.9	87	86.8	06.1	147	146.6	10.3	207	206.5	14.4	267	266.3	18.6
28	27.9	02.0	88	87.8	06.1	148	147.6	10.3	208	207.5	14.5	268	267.3	18.7
29	28.9	02.0	89	88.8	06.2	149	148.6	10.4	209	208.5	14.6	269	268.3	18.8
30	29.9	02.1	90	89.8	06.3	150	149.6	10.5	210	209.5	14.6	270	269.3	18.8
31	30.9	02.2	91	90.8	06.3	151	150.6	10.5	211	210.5	14.7	271	270.3	18.9
32	31.9	02.2	92	91.8	06.4	152	151.6	10.6	212	211.5	14.8	272	271.3	19.0
33	32.9	02.3	93	92.8	06.5	153	152.6	10.7	213	212.5	14.9	273	272.3	19.0
34	33.9	02.4	94	93.8	06.6	154	153.6	10.7	214	213.5	14.9	274	273.3	19.1
35	34.9	02.4	95	94.8	06.6	155	154.6	10.8	215	214.5	15.0	275	274.3	19.2
36	35.9	02.5	96	95.8	06.7	156	155.6	10.9	216	215.5	15.1	276	275.3	19.3
37	36.9	02.6	97	96.8	06.8	157	156.6	11.0	217	216.5	15.1	277	276.3	19.3
38	37.9	02.7	98	97.8	06.8	158	157.6	11.0	218	217.5	15.2	278	277.3	19.4
39	38.9	02.7	99	98.8	06.9	159	158.6	11.1	219	218.5	15.3	279	278.3	19.5
40	39.9	02.8	100	99.8	07.0	160	159.6	11.2	220	219.5	15.3	280	279.3	19.5
41	40.9	02.9	101	100.8	07.0	161	160.6	11.2	221	220.5	15.4	281	280.3	19.6
42	41.9	02.9	102	101.8	07.1	162	161.6	11.3	222	221.5	15.5	282	281.3	19.7
43	42.9	03.0	103	102.7	07.2	163	162.6	11.4	223	222.5	15.6	283	282.3	19.7
44	43.9	03.1	104	103.7	07.3	164	163.6	11.4	224	223.5	15.6	284	283.3	19.8
45	44.9	03.1	105	104.7	07.3	165	164.6	11.5	225	224.5	15.7	285	284.3	19.9
46	45.9	03.2	106	105.7	07.4	166	165.6	11.6	226	225.4	15.8	286	285.3	20.0
47	46.9	03.3	107	106.7	07.5	167	166.6	11.6	227	226.4	15.8	287	286.3	20.0
48	47.9	03.3	108	107.7	07.5	168	167.6	11.7	228	227.4	15.9	288	287.3	20.1
49	48.9	03.4	109	108.7	07.6	169	168.6	11.8	229	228.4	16.0	289	288.3	20.2
50	49.9	03.5	110	109.7	07.7	170	169.6	11.9	230	229.4	16.0	290	289.3	20.2
51	50.9	03.6	111	110.7	07.7	171	170.6	11.9	231	230.4	16.1	291	290.3	20.3
52	51.9	03.6	112	111.7	07.8	172	171.6	12.0	232	231.4	16.2	292	291.3	20.4
53	52.9	03.7	113	112.7	07.9	173	172.6	12.1	233	232.4	16.3	293	292.3	20.4
54	53.9	03.8	114	113.7	08.0	174	173.6	12.1	234	233.4	16.3	294	293.3	20.5
55	54.9	03.8	115	114.7	08.0	175	174.6	12.2	235	234.4	16.4	295	294.3	20.6
56	55.9	03.9	116	115.7	08.1	176	175.6	12.3	236	235.4	16.5	296	295.3	20.6
57	56.9	04.0	117	116.7	08.2	177	176.6	12.3	237	236.4	16.5	297	296.3	20.7
58	57.9	04.0	118	117.7	08.2	178	177.6	12.4	238	237.4	16.6	298	297.3	20.8
59	58.9	04.1	119	118.7	08.3	179	178.6	12.5	239	238.4	16.7	299	298.3	20.9
60	59.9	04.2	120	119.7	08.4	180	179.6	12.6	240	239.4	16.7	300	299.3	20.9
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

TABLE II.

Difference of Latitude and Departure for 5°.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	01.0	00.1	61	60.8	05.3	121	120.5	10.5	181	180.3	15.8	241	240.1	21.0
2	02.0	00.2	62	61.8	05.4	122	121.5	10.6	182	181.3	15.9	242	241.1	21.1
3	03.0	00.3	63	62.8	05.5	123	122.5	10.7	183	182.3	15.9	243	242.1	21.2
4	04.0	00.3	64	63.8	05.6	124	123.5	10.8	184	183.3	16.0	244	243.1	21.3
5	05.0	00.4	65	64.8	05.7	125	124.5	10.9	185	184.3	16.1	245	244.1	21.4
6	06.0	00.5	66	65.7	05.8	126	125.5	11.0	186	185.3	16.2	246	245.1	21.4
7	07.0	00.6	67	66.7	05.8	127	126.5	11.1	187	186.3	16.3	247	246.1	21.5
8	08.0	00.7	68	67.7	05.9	128	127.5	11.2	188	187.3	16.4	248	247.1	21.6
9	09.0	00.8	69	68.7	06.0	129	128.5	11.2	189	188.3	16.5	249	248.1	21.7
10	10.0	00.9	70	69.7	06.1	130	129.5	11.3	190	189.3	16.6	250	249.0	21.8
11	11.0	01.0	71	70.7	06.2	131	130.5	11.4	191	190.3	16.6	251	250.0	21.9
12	12.0	01.0	72	71.7	06.3	132	131.5	11.5	192	191.3	16.7	252	251.0	22.0
13	13.0	01.1	73	72.7	06.4	133	132.5	11.6	193	192.3	16.8	253	252.0	22.1
14	13.9	01.2	74	73.7	06.4	134	133.5	11.7	194	193.3	16.9	254	253.0	22.1
15	14.9	01.3	75	74.7	06.5	135	134.5	11.8	195	194.3	17.0	255	254.0	22.2
16	15.9	01.4	76	75.7	06.6	136	135.5	11.9	196	195.3	17.1	256	255.0	22.3
17	16.9	01.5	77	76.7	06.7	137	136.5	11.9	197	196.3	17.2	257	256.0	22.4
18	17.9	01.6	78	77.7	06.8	138	137.5	12.0	198	197.2	17.3	258	257.0	22.5
19	18.9	01.7	79	78.7	06.9	139	138.5	12.1	199	198.2	17.3	259	258.0	22.6
20	19.9	01.7	80	79.7	07.0	140	139.5	12.2	200	199.2	17.4	260	259.0	22.7
21	20.9	01.8	81	80.7	07.1	141	140.5	12.3	201	200.2	17.5	261	260.0	22.7
22	21.9	01.9	82	81.7	07.1	142	141.5	12.4	202	201.2	17.6	262	261.0	22.8
23	22.9	02.0	83	82.7	07.2	143	142.5	12.5	203	202.2	17.7	263	262.0	22.9
24	23.9	02.1	84	83.7	07.3	144	143.5	12.6	204	203.2	17.8	264	263.0	23.0
25	24.9	02.2	85	84.7	07.4	145	144.4	12.6	205	204.2	17.9	265	264.0	23.1
26	25.9	02.3	86	85.7	07.5	146	145.4	12.7	206	205.2	18.0	266	265.0	23.2
27	26.9	02.4	87	86.7	07.6	147	146.4	12.8	207	206.2	18.0	267	266.0	23.3
28	27.9	02.4	88	87.7	07.7	148	147.4	12.9	208	207.2	18.1	268	267.0	23.4
29	28.9	02.5	89	88.7	07.8	149	148.4	13.0	209	208.2	18.2	269	268.0	23.4
30	29.9	02.6	90	89.7	07.8	150	149.4	13.1	210	209.2	18.3	270	269.0	23.5
31	30.9	02.7	91	90.7	07.9	151	150.4	13.2	211	210.2	18.4	271	270.0	23.6
32	31.9	02.8	92	91.6	08.0	152	151.4	13.2	212	211.2	18.5	272	271.0	23.7
33	32.9	02.9	93	92.6	08.1	153	152.4	13.3	213	212.2	18.6	273	272.0	23.8
34	33.9	03.0	94	93.6	08.2	154	153.4	13.4	214	213.2	18.7	274	273.0	23.9
35	34.9	03.1	95	94.6	08.3	155	154.4	13.5	215	214.2	18.7	275	274.0	24.0
36	35.9	03.1	96	95.6	08.4	156	155.4	13.6	216	215.2	18.8	276	274.9	24.1
37	36.9	03.2	97	96.6	08.5	157	156.4	13.7	217	216.2	18.9	277	275.9	24.1
38	37.9	03.3	98	97.6	08.5	158	157.4	13.8	218	217.2	19.0	278	276.9	24.2
39	38.9	03.4	99	98.6	08.6	159	158.4	13.9	219	218.2	19.1	279	277.9	24.3
40	39.8	03.5	100	99.6	08.7	160	159.4	13.9	220	219.2	19.2	280	278.9	24.4
41	40.8	03.6	101	100.6	08.8	161	160.4	14.0	221	220.2	19.3	281	279.9	24.5
42	41.8	03.7	102	101.6	08.9	162	161.4	14.1	222	221.2	19.3	282	280.9	24.6
43	42.8	03.7	103	102.6	09.0	163	162.4	14.2	223	222.2	19.4	283	281.9	24.7
44	43.8	03.8	104	103.6	09.1	164	163.4	14.3	224	223.1	19.5	284	282.9	24.8
45	44.8	03.9	105	104.6	09.2	165	164.4	14.4	225	224.1	19.6	285	283.9	24.8
46	45.8	04.0	106	105.6	09.2	166	165.4	14.5	226	225.1	19.7	286	284.9	24.9
47	46.8	04.1	107	106.6	09.3	167	166.4	14.6	227	226.1	19.8	287	285.9	25.0
48	47.8	04.2	108	107.6	09.4	168	167.4	14.6	228	227.1	19.9	288	286.9	25.1
49	48.8	04.3	109	108.6	09.5	169	168.4	14.7	229	228.1	20.0	289	287.9	25.2
50	49.8	04.4	110	109.6	09.6	170	169.4	14.8	230	229.1	20.0	290	288.9	25.3
51	50.8	04.4	111	110.6	09.7	171	170.3	14.9	231	230.1	20.1	291	289.9	25.4
52	51.8	04.5	112	111.6	09.8	172	171.3	15.0	232	231.1	20.2	292	290.9	25.4
53	52.8	04.6	113	112.6	09.8	173	172.3	15.1	233	232.1	20.3	293	291.9	25.5
54	53.8	04.7	114	113.6	09.9	174	173.3	15.2	234	233.1	20.4	294	292.9	25.6
55	54.8	04.8	115	114.6	10.0	175	174.3	15.3	235	234.1	20.5	295	293.9	25.7
56	55.8	04.9	116	115.6	10.1	176	175.3	15.3	236	235.1	20.6	296	294.9	25.8
57	56.8	05.0	117	116.6	10.2	177	176.3	15.4	237	236.1	20.7	297	295.9	25.9
58	57.8	05.1	118	117.6	10.3	178	177.3	15.5	238	237.1	20.7	298	296.9	26.0
59	58.8	05.1	119	118.5	10.4	179	178.3	15.6	239	238.1	20.8	299	297.9	26.1
60	59.8	05.2	120	119.5	10.5	180	179.3	15.7	240	239.1	20.9	300	298.9	26.1
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Difference of Latitude and Departure for 6°.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	01.0	00.1	61	60.7	06.4	121	120.3	12.6	181	180.0	18.9	241	239.7	25.2
2	02.0	00.2	62	61.7	06.5	122	121.3	12.8	182	181.0	19.0	242	240.7	25.3
3	03.0	00.3	63	62.7	06.6	123	122.3	12.9	183	182.0	19.1	243	241.7	25.4
4	04.0	00.4	64	63.6	06.7	124	123.3	13.0	184	183.0	19.2	244	242.7	25.5
5	05.0	00.5	65	64.6	06.8	125	124.3	13.1	185	184.0	19.3	245	243.7	25.6
6	06.0	00.6	66	65.6	06.9	126	125.3	13.2	186	185.0	19.4	246	244.7	25.7
7	07.0	00.7	67	66.6	07.0	127	126.3	13.3	187	186.0	19.5	247	245.6	25.8
8	08.0	00.8	68	67.6	07.1	128	127.3	13.4	188	187.0	19.7	248	246.6	25.9
9	09.0	00.9	69	68.6	07.2	129	128.3	13.5	189	188.0	19.8	249	247.6	26.0
10	09.9	01.0	70	69.6	07.3	130	129.3	13.6	190	189.0	19.9	250	248.6	26.1
11	10.9	01.1	71	70.6	07.4	131	130.3	13.7	191	190.0	20.0	251	249.6	26.2
12	11.9	01.3	72	71.6	07.5	132	131.3	13.8	192	190.9	20.1	252	250.6	26.3
13	12.9	01.4	73	72.6	07.6	133	132.3	13.9	193	191.9	20.2	253	251.6	26.4
14	13.9	01.5	74	73.6	07.7	134	133.3	14.0	194	192.9	20.3	254	252.6	26.6
15	14.9	01.6	75	74.6	07.8	135	134.3	14.1	195	193.9	20.4	255	253.6	26.7
16	15.9	01.7	76	75.6	07.9	136	135.3	14.2	196	194.9	20.5	256	254.6	26.8
17	16.9	01.8	77	76.6	08.0	137	136.2	14.3	197	195.9	20.6	257	255.6	26.9
18	17.9	01.9	78	77.6	08.2	138	137.2	14.4	198	196.9	20.7	258	256.6	27.0
19	18.9	02.0	79	78.6	08.3	139	138.2	14.5	199	197.9	20.8	259	257.6	27.1
20	19.9	02.1	80	79.6	08.4	140	139.2	14.6	200	198.9	20.9	260	258.6	27.2
21	20.9	02.2	81	80.6	08.5	141	140.2	14.7	201	199.9	21.0	261	259.6	27.3
22	21.9	02.3	82	81.6	08.6	142	141.2	14.8	202	200.9	21.1	262	260.6	27.4
23	22.9	02.4	83	82.5	08.7	143	142.2	14.9	203	201.9	21.2	263	261.6	27.5
24	23.9	02.5	84	83.5	08.8	144	143.2	15.1	204	202.9	21.3	264	262.6	27.6
25	24.9	02.6	85	84.5	08.9	145	144.2	15.2	205	203.9	21.4	265	263.5	27.7
26	25.9	02.7	86	85.5	09.0	146	145.2	15.3	206	204.9	21.5	266	264.5	27.8
27	26.9	02.8	87	86.5	09.1	147	146.2	15.4	207	205.9	21.6	267	265.5	27.9
28	27.8	02.9	88	87.5	09.2	148	147.2	15.5	208	206.9	21.7	268	266.5	28.0
29	28.8	03.0	89	88.5	09.3	149	148.2	15.6	209	207.9	21.8	269	267.5	28.1
30	29.8	03.1	90	89.5	09.4	150	149.2	15.7	210	208.8	22.0	270	268.5	28.2
31	30.8	03.2	91	90.5	09.5	151	150.2	15.8	211	209.8	22.1	271	269.5	28.3
32	31.8	03.3	92	91.5	09.6	152	151.2	15.9	212	210.8	22.2	272	270.5	28.4
33	32.8	03.4	93	92.5	09.7	153	152.2	16.0	213	211.8	22.3	273	271.5	28.5
34	33.8	03.6	94	93.5	09.8	154	153.2	16.1	214	212.8	22.4	274	272.5	28.6
35	34.8	03.7	95	94.5	09.9	155	154.2	16.2	215	213.8	22.5	275	273.5	28.7
36	35.8	03.8	96	95.5	10.0	156	155.1	16.3	216	214.8	22.6	276	274.5	28.8
37	36.8	03.9	97	96.5	10.1	157	156.1	16.4	217	215.8	22.7	277	275.5	29.0
38	37.8	04.0	98	97.5	10.2	158	157.1	16.5	218	216.8	22.8	278	276.5	29.1
39	38.8	04.1	99	98.5	10.3	159	158.1	16.6	219	217.8	22.9	279	277.5	29.2
40	39.8	04.2	100	99.5	10.5	160	159.1	16.7	220	218.8	23.0	280	278.5	29.3
41	40.8	04.3	101	100.4	10.6	161	160.1	16.8	221	219.8	23.1	281	279.5	29.4
42	41.8	04.4	102	101.4	10.7	162	161.1	16.9	222	220.8	23.2	282	280.5	29.5
43	42.8	04.5	103	102.4	10.8	163	162.1	17.0	223	221.8	23.3	283	281.4	29.6
44	43.8	04.6	104	103.4	10.9	164	163.1	17.1	224	222.8	23.4	284	282.4	29.7
45	44.8	04.7	105	104.4	11.0	165	164.1	17.2	225	223.8	23.5	285	283.4	29.8
46	45.7	04.8	106	105.4	11.1	166	165.1	17.4	226	224.8	23.6	286	284.4	29.9
47	46.7	04.9	107	106.4	11.2	167	166.1	17.5	227	225.8	23.7	287	285.4	30.0
48	47.7	05.0	108	107.4	11.3	168	167.1	17.6	228	226.8	23.8	288	286.4	30.1
49	48.7	05.1	109	108.4	11.4	169	168.1	17.7	229	227.7	23.9	289	287.4	30.2
50	49.7	05.2	110	109.4	11.5	170	169.1	17.8	230	228.7	24.0	290	288.4	30.3
51	50.7	05.3	111	110.4	11.6	171	170.1	17.9	231	229.7	24.1	291	289.4	30.4
52	51.7	05.4	112	111.4	11.7	172	171.1	18.0	232	230.7	24.3	292	290.4	30.5
53	52.7	05.5	113	112.4	11.8	173	172.1	18.1	233	231.7	24.4	293	291.4	30.6
54	53.7	05.6	114	113.4	11.9	174	173.0	18.2	234	232.7	24.5	294	292.4	30.7
55	54.7	05.7	115	114.4	12.0	175	174.0	18.3	235	233.7	24.6	295	293.4	30.8
56	55.7	05.9	116	115.4	12.1	176	175.0	18.4	236	234.7	24.7	296	294.4	30.9
57	56.7	06.0	117	116.4	12.2	177	176.0	18.5	237	235.7	24.8	297	295.4	31.0
58	57.7	06.1	118	117.4	12.3	178	177.0	18.6	238	236.7	24.9	298	296.4	31.1
59	58.7	06.2	119	118.3	12.4	179	178.0	18.7	239	237.7	25.0	299	297.4	31.3
60	59.7	06.3	120	119.3	12.5	180	179.0	18.8	240	238.7	25.1	300	298.4	31.4
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Difference of Latitude and Departure for 7°.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	01.0	00.1	61	60.5	07.4	121	120.1	14.7	181	179.7	22.1	241	239.2	29.4
2	02.0	00.2	62	61.5	07.6	122	121.1	14.9	182	180.6	22.2	242	240.2	29.5
3	03.0	00.4	63	62.5	07.7	123	122.1	15.0	183	181.6	22.3	243	241.2	29.6
4	04.0	00.5	64	63.5	07.8	124	123.1	15.1	184	182.6	22.4	244	242.2	29.7
5	05.0	00.6	65	64.5	07.9	125	124.1	15.2	185	183.6	22.5	245	243.2	29.9
6	06.0	00.7	66	65.5	08.0	126	125.1	15.4	186	184.6	22.7	246	244.2	30.0
7	06.9	00.9	67	66.5	08.2	127	126.1	15.5	187	185.6	22.8	247	245.2	30.1
8	07.9	01.0	68	67.5	08.3	128	127.0	15.6	188	186.6	22.9	248	246.2	30.2
9	08.9	01.1	69	68.5	08.4	129	128.0	15.7	189	187.6	23.0	249	247.1	30.3
10	09.9	01.2	70	69.5	08.5	130	129.0	15.8	190	188.6	23.2	250	248.1	30.5
11	10.9	01.3	71	70.5	08.7	131	130.0	16.0	191	189.6	23.3	251	249.1	30.6
12	11.9	01.5	72	71.5	08.8	132	131.0	16.1	192	190.6	23.4	252	250.1	30.7
13	12.9	01.6	73	72.5	08.9	133	132.0	16.2	193	191.6	23.5	253	251·1	30.8
14	13.9	01.7	74	73.4	09.0	134	133.0	16.3	194	192.6	23.6	254	252.1	31.0
15	14.9	01.8	75	74.4	09.1	135	134.0	16.5	195	193.5	23.8	255	253.1	31.1
16	15.9	01.9	76	75.4	09.3	136	135.0	16.6	196	194.5	23.9	256	254.1	31.2
17	16.9	02.1	77	76.4	09.4	137	136.0	16.7	197	195.5	24.0	257	255.1	31.3
18	17.9	02.2	78	77.4	09.5	138	137.0	16.8	198	196.5	24.1	258	256.1	31.4
19	18.9	02.3	79	78.4	09.6	139	138.0	16.9	199	197.5	24.3	259	257.1	31.6
20	19.9	02.4	80	79.4	09.7	140	139.0	17.1	200	198.5	24.4	260	258.1	31.7
21	20.8	02.6	81	80.4	09.9	141	139.9	17.2	201	199.5	24.5	261	259.1	31.8
22	21.8	02.7	82	81.4	10.0	142	140.9	17.3	202	200.5	24.6	262	260.0	31.9
23	22.8	02.8	83	82.4	10.1	143	141.9	17.4	203	201.5	24.7	263	261.0	32.1
24	23.8	02.9	84	83.4	10.2	144	142.9	17.5	204	202.5	24.9	264	262.0	32.2
25	24.8	03.0	85	84.4	10.4	145	143.9	17.7	205	203.5	25.0	265	263.0	32.3
26	25.8	03.2	86	85.4	10.5	146	144.9	17.8	206	204.5	25.1	266	264.0	32.4
27	26.8	03.3	87	86.4	10.6	147	145.9	17.9	207	205.5	25.2	267	265.0	32.5
28	27.8	03.4	88	87.3	10.7	148	146.9	18.0	208	206.4	25.3	268	266.0	32.7
29	28.8	03.5	89	88.3	10.8	149	147.9	18.2	209	207.4	25.5	269	267.0	32.8
30	29.8	03.7	90	89.3	11.0	150	148.9	18.3	210	208.4	25.6	270	268.0	32.9
31	30.8	03.8	91	90.3	11.1	151	149.9	18.4	211	209.4	25.7	271	269.0	33.0
32	31.8	03.9	92	91.3	11.2	152	150.9	18.5	212	210.4	25.8	272	270.0	33.1
33	32.8	04.0	93	92.3	11.3	153	151.9	18.6	213	211.4	26.0	273	271.0	33.3
34	33.7	04.1	94	93.3	11.5	154	152.9	18.8	214	212.4	26.1	274	272.0	33.4
35	34.7	04.3	95	94.3	11.6	155	153.8	18.9	215	213.4	26.2	275	273.0	33.5
36	35.7	04.4	96	95.3	11.7	156	154.8	19.0	216	214.4	26.3	276	273.9	33.6
37	36.7	04.5	97	96.3	11.8	157	155.8	19.1	217	215.4	26.4	277	274.9	33.8
38	37.7	04.6	98	97.3	11.9	158	156.8	19.3	218	216.4	26.6	278	275.9	33.9
39	38.7	04.8	99	98.3	12.1	159	157.8	19.4	219	217.4	26.7	279	276.9	34.0
40	39.7	04.9	100	99.3	12.2	160	158.8	19.5	220	218.4	26.8	280	277.9	34.1
41	40.7	05.0	101	100.2	12.3	161	159.8	19.6	221	219.4	26.9	281	278.9	34.2
42	41.7	05.1	102	101.2	12.4	162	160.8	19.7	222	220.3	27.1	282	279.9	34.4
43	42.7	05.2	103	102.2	12.6	163	161.8	19.9	223	221.3	27.2	283	280.9	34.5
44	43.7	05.4	104	103.2	12.7	164	162.8	20.0	224	222.3	27.3	284	281.9	34.6
45	44.7	05.5	105	104.2	12.8	165	163.8	20.1	225	223.3	27.4	285	282.9	34.7
46	45.7	05.6	106	105.2	12.9	166	164.8	20.2	226	224.3	27.5	286	283.9	34.9
47	46.6	05.7	107	106.2	13.0	167	165.8	20.4	227	225.3	27.7	287	284.9	35.0
48	47.6	05.8	108	107.2	13.2	168	166.7	20.5	228	226.3	27.8	288	285.9	35.1
49	48.6	06.0	109	108.2	13.3	169	167.7	20.6	229	227.3	27.9	289	286.8	35.2
50	49.6	06.1	110	109.2	13.4	170	168.7	20.7	230	228.3	28.0	290	287.8	35.3
51	50.6	06.2	111	110.2	13.5	171	169.7	20.8	231	229.3	28.2	291	288.8	35.5
52	51.6	06.3	112	111.2	13.6	172	170.7	21.0	232	230.3	28.3	292	289.8	35.6
53	52.6	06.5	113	112.2	13.8	173	171.7	21.1	233	231.3	28.4	293	290.8	35.7
54	53.6	06.6	114	113.2	13.9	174	172.7	21.2	234	232.3	28.5	294	291.8	35.8
55	54.6	06.7	115	114.1	14.0	175	173.7	21.3	235	233.2	28.6	295	292.8	36.0
56	55.6	06.8	116	115.1	14.1	176	174.7	21.4	236	234.2	28.8	296	293.8	36.1
57	56.6	06.9	117	116.1	14.3	177	175.7	21.6	237	235.2	28.9	297	294.8	36.2
58	57.6	07.1	118	117.1	14.4	178	176.7	21.7	238	236.2	29.0	298	295.8	36.3
59	58.6	07.2	119	118.1	14.5	179	177.7	21.8	239	237.2	29.1	299	296.8	36.4
60	59.6	07.3	120	119.1	14.6	180	178.7	21.9	240	238.2	29.2	300	297.8	36.6
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

TABLE II.

Difference of Latitude and Departure for 8°.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	01.0	00.1	61	60.4	08.5	121	119.8	16.8	181	179.2	25.2	241	238.7	33.5
2	02.0	00.3	62	61.4	08.6	122	120.8	17.0	182	180.2	25.3	242	239.6	33.7
3	03.0	00.4	63	62.4	08.8	123	121.8	17.1	183	181.2	25.5	243	240.6	33.8
4	04.0	00.6	64	63.4	08.9	124	122.8	17.3	184	182.2	25.6	244	241.6	34.0
5	05.0	00.7	65	64.4	09.0	125	123.8	17.4	185	183.2	25.7	245	242.6	34.1
6	05.9	00.8	66	65.4	09.2	126	124.8	17.5	186	184.2	25.9	246	243.6	34.2
7	06.9	01.0	67	66.3	09.3	127	125.8	17.7	187	185.2	26.0	247	244.6	34.4
8	07.9	01.1	68	67.3	09.5	128	126.8	17.8	188	186.2	26.2	248	245.6	34.5
9	08.9	01.3	69	68.3	09.6	129	127.7	18.0	189	187.2	26.3	249	246.6	34.7
10	09.9	01.4	70	69.3	09.7	130	128.7	18.1	190	188.2	26.4	250	247.6	34.8
11	10.9	01.5	71	70.3	09.9	131	129.7	18.2	191	189.1	26.6	251	248.6	34.9
12	11.9	01.7	72	71.3	10.0	132	130.7	18.4	192	190.1	26.7	252	249.5	35.1
13	12.9	01.8	73	72.3	10.2	133	131.7	18.5	193	191.1	26.9	253	250.5	35.2
14	13.9	01.9	74	73.3	10.3	134	132.7	18.6	194	192.1	27.0	254	251.5	35.3
15	14.9	02.1	75	74.3	10.4	135	133.7	18.8	195	193.1	27.1	255	252.5	35.5
16	15.8	02.2	76	75.3	10.6	136	134.7	18.9	196	194.1	27.3	256	253.5	35.6
17	16.8	02.4	77	76.3	10.7	137	135.7	19.1	197	195.1	27.4	257	254.5	35.8
18	17.8	02.5	78	77.2	10.9	138	136.7	19.2	198	196.1	27.6	258	255.5	35.9
19	18.8	02.6	79	78.2	11.0	139	137.7	19.3	199	197.1	27.7	259	256.5	36.0
20	19.8	02.8	80	79.2	11.1	140	138.6	19.5	200	198.1	27.8	260	257.5	36.2
21	20.8	02.9	81	80.2	11.3	141	139.6	19.6	201	199.0	28.0	261	258.5	36.3
22	21.8	03.1	82	81.2	11.4	142	140.6	19.8	202	200.0	28.1	262	259.5	36.5
23	22.8	03.2	83	82.2	11.6	143	141.6	19.9	203	201.0	28.3	263	260.4	36.6
24	23.8	03.3	84	83.2	11.7	144	142.6	20.0	204	202.0	28.4	264	261.4	36.7
25	24.8	03.5	85	84.2	11.8	145	143.6	20.2	205	203.0	28.5	265	262.4	36.9
26	25.7	03.6	86	85.2	12.0	146	144.6	20.3	206	204.0	28.7	266	263.4	37.0
27	26.7	03.8	87	86.2	12.1	147	145.6	20.5	207	205.0	28.8	267	264.4	37.2
28	27.7	03.9	88	87.1	12.2	148	146.6	20.6	208	206.0	28.9	268	265.4	37.3
29	28.7	04.0	89	88.1	12.4	149	147.5	20.7	209	207.0	29.1	269	266.4	37.4
30	29.7	04.2	90	89.1	12.5	150	148.5	20.9	210	208.0	29.2	270	267.4	37.6
31	30.7	04.3	91	90.1	12.7	151	149.5	21.0	211	208.9	29.4	271	268.4	37.7
32	31.7	04.5	92	91.1	12.8	152	150.5	21.2	212	209.9	29.5	272	269.4	37.9
33	32.7	04.6	93	92.1	12.9	153	151.5	21.3	213	210.9	29.6	273	270.3	38.0
34	33.7	04.7	94	93.1	13.1	154	152.5	21.4	214	211.9	29.8	274	271.3	38.1
35	34.7	04.9	95	94.1	13.2	155	153.5	21.6	215	212.9	29.9	275	272.3	38.3
36	35.6	05.0	96	95.1	13.4	156	154.5	21.7	216	213.9	30.1	276	273.3	38.4
37	36.6	05.1	97	96.1	13.5	157	155.5	21.9	217	214.9	30.2	277	274.3	38.6
38	37.6	05.3	98	97.0	13.6	158	156.5	22.0	218	215.9	30.3	278	275.3	38.7
39	38.6	05.4	99	98.0	13.8	159	157.5	22.1	219	216.9	30.5	279	276.3	38.8
40	39.6	05.6	100	99.0	13.9	160	158.4	22.3	220	217.9	30.6	280	277.3	39.0
41	40.6	05.7	101	100.0	14.1	161	159.4	22.4	221	218.8	30.8	281	278.3	39.1
42	41.6	05.8	102	101.0	14.2	162	160.4	22.5	222	219.8	30.9	282	279.3	39.2
43	42.6	06.0	103	102.0	14.3	163	161.4	22.7	223	220.8	31.0	283	280.2	39.4
44	43.6	06.1	104	103.0	14.5	164	162.4	22.8	224	221.8	31.2	284	281.2	39.5
45	44.6	06.3	105	104.0	14.6	165	163.4	23.0	225	222.8	31.3	285	282.2	39.7
46	45.6	06.4	106	105.0	14.8	166	164.4	23.1	226	223.8	31.5	286	283.2	39.8
47	46.5	06.5	107	106.0	14.9	167	165.4	23.2	227	224.8	31.6	287	284.2	39.9
48	47.5	06.7	108	106.9	15.0	168	166.4	23.4	228	225.8	31.7	288	285.2	40.1
49	48.5	06.8	109	107.9	15.2	169	167.4	23.5	229	226.8	31.9	289	286.2	40.2
50	49.5	07.0	110	108.9	15.3	170	168.3	23.7	230	227.8	32.0	290	287.2	40.4
51	50.5	07.1	111	109.9	15.4	171	169.3	23.8	231	228.8	32.1	291	288.2	40.5
52	51.5	07.2	112	110.9	15.6	172	170.3	23.9	232	229.7	32.3	292	289.2	40.6
53	52.5	07.4	113	111.9	15.7	173	171.3	24.1	233	230.7	32.4	293	290.1	40.8
54	53.5	07.5	114	112.9	15.9	174	172.3	24.2	234	231.7	32.6	294	291.1	40.9
55	54.5	07.7	115	113.9	16.0	175	173.3	24.4	235	232.7	32.7	295	292.1	41.1
56	55.5	07.8	116	114.9	16.1	176	174.3	24.5	236	233.7	32.8	296	293.1	41.2
57	56.4	07.9	117	115.9	16.3	177	175.3	24.6	237	234.7	33.0	297	294.1	41.3
58	57.4	08.1	118	116.9	16.4	178	176.3	24.8	238	235.7	33.1	298	295.1	41.5
59	58.4	08.2	119	117.8	16.6	179	177.3	24.9	239	236.7	33.3	299	296.1	41.6
60	59.4	08.4	120	118.8	16.7	180	178.2	25.1	240	237.7	33.4	300	297.1	41.8
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Difference of Latitude and Departure for 9°.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep
1	01.0	00.2	61	60.2	09.5	121	119.5	18.9	181	178.8	28.3	241	238.0	37.7
2	02.0	00.3	62	61.2	09.7	122	120.5	19.1	182	179.8	28.5	242	239.0	37.9
3	03.0	00.5	63	62.2	09.9	123	121.5	19.2	183	180.7	28.6	243	240.0	38.0
4	04.0	00.6	64	63.2	10.0	124	122.5	19.4	184	181.7	28.8	244	241.0	38.2
5	04.9	00.8	65	64.2	10.2	125	123.5	19.6	185	182.7	28.9	245	242.0	38.3
6	05.9	00.9	66	65.2	10.3	126	124.4	19.7	186	183.7	29.1	246	243.0	38.5
7	06.9	01.1	67	66.2	10.5	127	125.4	19.9	187	184.7	29.3	247	244.0	38.6
8	07.9	01.3	68	67.2	10.6	128	126.4	20.0	188	185.7	29.4	248	244.9	38.8
9	08.9	01.4	69	68.2	10.8	129	127.4	20.2	189	186.7	29.6	249	245.9	39.0
10	09.9	01.6	70	69.1	11.0	130	128.4	20.3	190	187.7	29.7	250	246.9	39.1
11	10.9	01.7	71	70.1	11.1	131	129.4	20.5	191	188.6	29.9	251	247.9	39.3
12	11.9	01.9	72	71.1	11.3	132	130.4	20.6	192	189.6	30.0	252	248.9	39.4
13	12.8	02.0	73	72.1	11.4	133	131.4	20.8	193	190.6	30.2	253	249.9	39.6
14	13.8	02.2	74	73.1	11.6	134	132.4	21.0	194	191.6	30.3	254	250.9	39.7
15	14.8	02.3	75	74.1	11.7	135	133.3	21.1	195	192.6	30.5	255	251.9	39.9
16	15.8	02.5	76	75.1	11.9	136	134.3	21.3	196	193.6	30.7	256	252.8	40.0
17	16.8	02.7	77	76.1	12.0	137	135.3	21.4	197	194.6	30.8	257	253.8	40.2
18	17.8	02.8	78	77.0	12.2	138	136.3	21.6	198	195.6	31.0	258	254.8	40.4
19	18.8	03.0	79	78.0	12.4	139	137.3	21.7	199	196.5	31.1	259	255.8	40.5
20	19.8	03.1	80	79.0	12.5	140	138.3	21.9	200	197.5	31.3	260	256.8	40.7
21	20.7	03.3	81	80.0	12.7	141	139.3	22.1	201	198.5	31.4	261	257.8	40.8
22	21.7	03.4	82	81.0	12.8	142	140.3	22.2	202	199.5	31.6	262	258.8	41.0
23	22.7	03.6	83	82.0	13.0	143	141.2	22.4	203	200.5	31.8	263	259.8	41.1
24	23.7	03.8	84	83.0	13.1	144	142.2	22.5	204	201.5	31.9	264	260.7	41.3
25	24.7	03.9	85	84.0	13.3	145	143.2	22.7	205	202.5	32.1	265	261.7	41.5
26	25.7	04.1	86	84.9	13.5	146	144.2	22.8	206	203.5	32.2	266	262.7	41.6
27	26.7	04.2	87	85.9	13.6	147	145.2	23.0	207	204.5	32.4	267	263.7	41.8
28	27.7	04.4	88	86.9	13.8	148	146.2	23.2	208	205.4	32.5	268	264.7	41.9
29	28.6	04.5	89	87.9	13.9	149	147.2	23.3	209	206.4	32.7	269	265.7	42.1
30	29.6	04.7	90	88.9	14.1	150	148.2	23.5	210	207.4	32.9	270	266.7	42.2
31	30.6	04.8	91	89.9	14.2	151	149.1	23.6	211	208.4	33.0	271	267.7	42.4
32	31.6	05.0	92	90.9	14.4	152	150.1	23.8	212	209.4	33.2	272	268.7	42.6
33	32.6	05.2	93	91.9	14.5	153	151.1	23.9	213	210.4	33.3	273	269.6	42.7
34	33.6	05.3	94	92.8	14.7	154	152.1	24.1	214	211.4	33.5	274	270.6	42.9
35	34.6	05.5	95	93.8	14.9	155	153.1	24.2	215	212.4	33.6	275	271.6	43.0
36	35.6	05.6	96	94.8	15.0	156	154.1	24.4	216	213.3	33.8	276	272.6	43.2
37	36.5	05.8	97	95.8	15.2	157	155.1	24.6	217	214.3	33.9	277	273.6	43.3
38	37.5	05.9	98	96.8	15.3	158	156.1	24.7	218	215.3	34.1	278	274.6	43.5
39	38.5	06.1	99	97.8	15.5	159	157.0	24.9	219	216.3	34.3	279	275.6	43.6
40	39.5	06.3	100	98.8	15.6	160	158.0	25.0	220	217.3	34.4	280	276.6	43.8
41	40.5	06.4	101	99.8	15.8	161	159.0	25.2	221	218.3	34.6	281	277.5	44.0
42	41.5	06.6	102	100.7	16.0	162	160.0	25.3	222	219.3	34.7	282	278.5	44.1
43	42.5	06.7	103	101.7	16.1	163	161.0	25.5	223	220.3	34.9	283	279.5	44.3
44	43.5	06.9	104	102.7	16.3	164	162.0	25.7	224	221.2	35.0	284	280.5	44.4
45	44.4	07.0	105	103.7	16.4	165	163.0	25.8	225	222.2	35.2	285	281.5	44.6
46	45.4	07.2	106	104.7	16.6	166	164.0	26.0	226	223.2	35.4	286	282.5	44.7
47	46.4	07.4	107	105.7	16.7	167	164.9	26.1	227	224.2	35.5	287	283.5	44.9
48	47.4	07.5	108	106.7	16.9	168	165.9	26.3	228	225.2	35.7	288	284.5	45.1
49	48.4	07.7	109	107.7	17.1	169	166.9	26.4	229	226.2	35.8	289	285.4	45.2
50	49.4	07.8	110	108.6	17.2	170	167.9	26.6	230	227.2	36.0	290	286.4	45.4
51	50.4	08.0	111	109.6	17.4	171	168.9	26.8	231	228.2	36.1	291	287.4	45.5
52	51.4	08.1	112	110.6	17.5	172	169.9	26.9	232	229.1	36.3	292	288.4	45.7
53	52.3	08.3	113	111.6	17.7	173	170.9	27.1	233	230.1	36.4	293	289.4	45.8
54	53.3	08.4	114	112.6	17.8	174	171.9	27.2	234	231.1	36.6	294	290.4	46.0
55	54.3	08.6	115	113.6	18.0	175	172.8	27.4	235	232.1	36.8	295	291.4	46.1
56	55.3	08.8	116	114.6	18.1	176	173.8	27.5	236	233.1	36.9	296	292.4	46.3
57	56.3	08.9	117	115.6	18.3	177	174.8	27.7	237	234.1	37.1	297	293.3	46.5
58	57.3	09.1	118	116.5	18.5	178	175.8	27.8	238	235.1	37.2	298	294.3	46.6
59	58.3	09.2	119	117.5	18.6	179	176.8	28.0	239	236.1	37.4	299	295.3	46.8
60	59.3	09.4	120	118.5	18.8	180	177.8	28.2	240	237.0	37.5	300	296.3	46.9
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

TABLE II.

Difference of Latitude and Departure for 10°.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	01.0	00.2	61	60.1	10.6	121	119.2	21.0	181	178.3	31.4	241	237.3	41.8
2	02.0	00.3	62	61.1	10.8	122	120.1	21.2	182	179.2	31.6	242	238.3	42.0
3	03.0	00.5	63	62.0	10.9	123	121.1	21.4	183	180.2	31.8	243	239.3	42.2
4	03.9	00.7	64	63.0	11.1	124	122.1	21.5	184	181.2	32.0	244	240.3	42.4
5	04.9	00.9	65	64.0	11.3	125	123.1	21.7	185	182.2	32.1	245	241.3	42.5
6	05.9	01.0	66	65.0	11.5	126	124.1	21.9	186	183.2	32.3	246	242.3	42.7
7	06.9	01.2	67	66.0	11.6	127	125.1	22.1	187	184.2	32.5	247	243.2	42.9
8	07.9	01.4	68	67.0	11.8	128	126.1	22.2	188	185.1	32.6	248	244.2	43.1
9	08.9	01.6	69	68.0	12.0	129	127.0	22.4	189	186.1	32.8	249	245.2	43.2
10	09.8	01.7	70	68.9	12.2	130	128.0	22.6	190	187.1	33.0	250	246.2	43.4
11	10.8	01.9	71	69.9	12.3	131	129.0	22.7	191	188.1	33.2	251	247.2	43.6
12	11.8	02.1	72	70.9	12.5	132	130.0	22.9	192	189.1	33.3	252	248.2	43.8
13	12.8	02.3	73	71.9	12.7	133	131.0	23.1	193	190.1	33.5	253	249.2	43.9
14	13.8	02.4	74	72.9	12.8	134	132.0	23.3	194	191.1	33.7	254	250.1	44.1
15	14.8	02.6	75	73.9	13.0	135	132.9	23.4	195	192.0	33.9	255	251.1	44.3
16	15.8	02.8	76	74.8	13.2	136	133.9	23.6	196	193.0	34.0	256	252.1	44.5
17	16.7	03.0	77	75.8	13.4	137	134.9	23.8	197	194.0	34.2	257	253.1	44.6
18	17.7	03.1	78	76.8	13.5	138	135.9	24.0	198	195.0	34.4	258	254.1	44.8
19	18.7	03.3	79	77.8	13.7	139	136.9	24.1	199	196.0	34.6	259	255.1	45.0
20	19.7	03.5	80	78.8	13.9	140	137.9	24.3	200	197.0	34.7	260	256.1	45.1
21	20.7	03.6	81	79.8	14.1	141	138.9	24.5	201	197.9	34.9	261	257.0	45.3
22	21.7	03.8	82	80.8	14.2	142	139.8	24.7	202	198.9	35.1	262	258.0	45.5
23	22.7	04.0	83	81.7	14.4	143	140.8	24.8	203	199.9	35.3	263	259.0	45.7
24	23.6	04.2	84	82.7	14.6	144	141.8	25.0	204	200.9	35.4	264	260.0	45.8
25	24.6	04.3	85	83.7	14.8	145	142.8	25.2	205	201.9	35.6	265	261.0	46.0
26	25.6	04.5	86	84.7	14.9	146	143.8	25.4	206	202.9	35.8	266	262.0	46.2
27	26.6	04.7	87	85.7	15.1	147	144.8	25.5	207	203.9	35.9	267	262.9	46.4
28	27.6	04.9	88	86.7	15.3	148	145.8	25.7	208	204.8	36.1	268	263.9	46.5
29	28.6	05.0	89	87.6	15.5	149	146.7	25.9	209	205.8	36.3	269	264.9	46.7
30	29.5	05.2	90	88.6	15.6	150	147.7	26.0	210	206.8	36.5	270	265.9	46.9
31	30.5	05.4	91	89.6	15.8	151	148.7	26.2	211	207.8	36.6	271	266.9	47.1
32	31.5	05.6	92	90.6	16.0	152	149.7	26.4	212	208.8	36.8	272	267.9	47.2
33	32.5	05.7	93	91.6	16.1	153	150.7	26.6	213	209.8	37.0	273	268.9	47.4
34	33.5	05.9	94	92.6	16.3	154	151.7	26.7	214	210.7	37.2	274	269.8	47.6
35	34.5	06.1	95	93.6	16.5	155	152.6	26.9	215	211.7	37.3	275	270.8	47.8
36	35.5	06.3	96	94.5	16.7	156	153.6	27.1	216	212.7	37.5	276	271.8	47.9
37	36.4	06.4	97	95.5	16.8	157	154.6	27.3	217	213.7	37.7	277	272.8	48.1
38	37.4	06.6	98	96.5	17.0	158	155.6	27.4	218	214.7	37.9	278	273.8	48.3
39	38.4	06.8	99	97.5	17.2	159	156.6	27.6	219	215.7	38.0	279	274.8	48.4
40	39.4	06.9	100	98.5	17.4	160	157.6	27.8	220	216.7	38.2	280	275.7	48.6
41	40.4	07.1	101	99.5	17.5	161	158.6	28.0	221	217.6	38.4	281	276.7	48.8
42	41.4	07.3	102	100.5	17.7	162	159.5	28.1	222	218.6	38.5	282	277.7	49.0
43	42.3	07.5	103	101.4	17.9	163	160.5	28.3	223	219.6	38.7	283	278.7	49.1
44	43.3	07.6	104	102.4	18.1	164	161.5	28.5	224	220.6	38.9	284	279.7	49.3
45	44.3	07.8	105	103.4	18.2	165	162.5	28.7	225	221.6	39.1	285	280.7	49.5
46	45.3	08.0	106	104.4	18.4	166	163.5	28.8	226	222.6	39.2	286	281.7	49.7
47	46.3	08.2	107	105.4	18.6	167	164.5	29.0	227	223.6	39.4	287	282.6	49.8
48	47.3	08.3	108	106.4	18.8	168	165.4	29.2	228	224.5	39.6	288	283.6	50.0
49	48.3	08.5	109	107.3	18.9	169	166.4	29.3	229	225.5	39.8	289	284.6	50.2
50	49.2	08.7	110	108.3	19.1	170	167.4	29.5	230	226.5	39.9	290	285.6	50.4
51	50.2	08.9	111	109.3	19.3	171	168.4	29.7	231	227.5	40.1	291	286.6	50.5
52	51.2	09.0	112	110.3	19.4	172	169.4	29.9	232	228.5	40.3	292	287.6	50.7
53	52.2	09.2	113	111.3	19.6	173	170.4	30.0	233	229.5	40.5	293	288.5	50.9
54	53.2	09.4	114	112.3	19.8	174	171.4	30.2	234	230.4	40.6	294	289.5	51.1
55	54.2	09.6	115	113.3	20.0	175	172.3	30.4	235	231.4	40.8	295	290.5	51.2
56	55.1	09.7	116	114.2	20.1	176	173.3	30.6	236	232.4	41.0	296	291.5	51.4
57	56.1	09.9	117	115.2	20.3	177	174.3	30.7	237	233.4	41.2	297	292.5	51.6
58	57.1	10.1	118	116.2	20.5	178	175.3	30.9	238	234.4	41.3	298	293.5	51.7
59	58.1	10.2	119	117.2	20.7	179	176.3	31.1	239	235.4	41.5	299	294.5	51.9
60	59.1	10.4	120	118.2	20.8	180	177.3	31.3	240	236.4	41.7	300	295.4	52.1
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Difference of Latitude and Departure for 11°.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	01.0	00.2	61	59.9	11.6	121	118.8	23.1	181	177.7	34.5	241	236.6	46.0
2	02.0	00.4	62	60.9	11.8	122	119.8	23.3	182	178.7	34.7	242	237.6	46.2
3	02.9	00.6	63	61.8	12.0	123	120.7	23.5	183	179.6	34.9	243	238.5	46.4
4	03.9	00.8	64	62.8	12.2	124	121.7	23.7	184	180.6	35.1	244	239.5	46.6
5	04.9	01.0	65	63.8	12.4	125	122.7	23.9	185	181.6	35.3	245	240.5	46.7
6	05.9	01.1	66	64.8	12.6	126	123.7	24.0	186	182.6	35.5	246	241.5	46.9
7	06.9	01.3	67	65.8	12.8	127	124.7	24.2	187	183.6	35.8	247	242.5	47.1
8	07.9	01.5	68	66.8	13.0	128	125.6	24.4	188	184.5	35.9	248	243.4	47.3
9	08.8	01.7	69	67.7	13.2	129	126.6	24.6	189	185.5	36.1	249	244.4	47.5
10	09.8	01.9	70	68.7	13.4	130	127.6	24.8	190	186.5	36.3	250	245.4	47.7
11	10.8	02.1	71	69.7	13.5	131	128.6	25.0	191	187.5	36.4	251	246.4	47.9
12	11.8	02.3	72	70.7	13.7	132	129.6	25.2	192	188.5	36.6	252	247.4	48.1
13	12.8	02.5	73	71.7	13.9	133	130.6	25.4	193	189.5	36.8	253	248.4	48.3
14	13.7	02.7	74	72.6	14.1	134	131.5	25.6	194	190.4	37.0	254	249.3	48.5
15	14.7	02.9	75	73.6	14.3	135	132.5	25.8	195	191.4	37.2	255	250.3	48.7
16	15.7	03.1	76	74.6	14.5	136	133.5	26.0	196	192.4	37.4	256	251.3	48.8
17	16.7	03.2	77	75.6	14.7	137	134.5	26.1	197	193.4	37.6	257	252.3	49.0
18	17.7	03.4	78	76.6	14.9	138	135.5	26.3	198	194.4	37.8	258	253.3	49.2
19	18.7	03.6	79	77.5	15.1	139	136.4	26.5	199	195.3	38.0	259	254.2	49.4
20	19.6	03.8	80	78.5	15.3	140	137.4	26.7	200	196.3	38.2	260	255.2	49.6
21	20.6	04.0	81	79.5	15.5	141	138.4	26.9	201	197.3	38.4	261	256.2	49.8
22	21.6	04.2	82	80.5	15.6	142	139.4	27.1	202	198.3	38.5	262	257.2	50.0
23	22.6	04.4	83	81.5	15.8	143	140.4	27.3	203	199.3	38.7	263	258.2	50.2
24	23.6	04.6	84	82.5	16.0	144	141.4	27.5	204	200.3	38.9	264	259.1	50.4
25	24.5	04.8	85	83.4	16.2	145	142.3	27.7	205	201.2	39.1	265	260.1	50.6
26	25.5	05.0	86	84.4	16.4	146	143.3	27.9	206	202.2	39.3	266	261.1	50.8
27	26.5	05.2	87	85.4	16.6	147	144.3	28.0	207	203.2	39.5	267	262.1	50.9
28	27.5	05.3	88	86.4	16.8	148	145.3	28.2	208	204.2	39.7	268	263.1	51.1
29	28.5	05.5	89	87.4	17.0	149	146.3	28.4	209	205.2	39.9	269	264.1	51.3
30	29.4	05.7	90	88.3	17.2	150	147.2	28.6	210	206.1	40.1	270	265.0	51.5
31	30.4	05.9	91	89.3	17.4	151	148.2	28.8	211	207.1	40.3	271	266.0	51.7
32	31.4	06.1	92	90.3	17.6	152	149.2	29.0	212	208.1	40.5	272	267.0	51.9
33	32.4	06.3	93	91.3	17.7	153	150.2	29.2	213	209.1	40.6	273	268.0	52.1
34	33.4	06.5	94	92.3	17.9	154	151.2	29.4	214	210.1	40.8	274	269.0	52.3
35	34.4	06.7	95	93.3	18.1	155	152.2	29.6	215	211.0	41.0	275	269.9	52.5
36	35.3	06.9	96	94.2	18.3	156	153.1	29.8	216	212.0	41.2	276	270.9	52.7
37	36.3	07.1	97	95.2	18.5	157	154.1	30.0	217	213.0	41.4	277	271.9	52.9
38	37.3	07.3	98	96.2	18.7	158	155.1	30.1	218	214.0	41.6	278	272.9	53.0
39	38.3	07.4	99	97.2	18.9	159	156.1	30.3	219	215.0	41.8	279	273.9	53.2
40	39.3	07.6	100	98.2	19.1	160	157.1	30.5	220	216.0	42.0	280	274.9	53.4
41	40.2	07.8	101	99.1	19.3	161	158.0	30.7	221	216.9	42.2	281	275.8	53.6
42	41.2	08.0	102	100.1	19.5	162	159.0	30.9	222	217.9	42.4	282	276.8	53.8
43	42.2	08.2	103	101.1	19.7	163	160.0	31.1	223	218.9	42.6	283	277.8	54.0
44	43.2	08.4	104	102.1	19.8	164	161.0	31.3	224	219.9	42.7	284	278.8	54.2
45	44.2	08.6	105	103.1	20.0	165	162.0	31.5	225	220.9	42.9	285	279.8	54.4
46	45.2	08.8	106	104.1	20.2	166	163.0	31.7	226	221.8	43.1	286	280.7	54.6
47	46.1	09.0	107	105.0	20.4	167	163.9	31.9	227	222.8	43.3	287	281.7	54.8
48	47.1	09.2	108	106.0	20.6	168	164.9	32.1	228	223.8	43.5	288	282.7	55.0
49	48.1	09.3	109	107.0	20.8	169	165.9	32.2	229	224.8	43.7	289	283.7	55.1
50	49.1	09.5	110	108.0	21.0	170	166.9	32.4	230	225.8	43.9	290	284.7	55.3
51	50.1	09.7	111	109.0	21.2	171	167.9	32.6	231	226.8	44.1	291	285.7	55.5
52	51.0	09.9	112	109.9	21.4	172	168.8	32.8	232	227.7	44.3	292	286.6	55.7
53	52.0	10.1	113	110.9	21.6	173	169.8	33.0	233	228.7	44.5	293	287.6	55.9
54	53.0	10.3	114	111.9	21.8	174	170.8	33.2	234	229.7	44.6	294	288.6	56.1
55	54.0	10.5	115	112.9	21.9	175	171.8	33.4	235	230.7	44.8	295	289.6	56.3
56	55.0	10.7	116	113.9	22.1	176	172.8	33.6	236	231.7	45.0	296	290.6	56.5
57	56.0	10.9	117	114.9	22.3	177	173.7	33.8	237	232.6	45.2	297	291.5	56.7
58	56.9	11.1	118	115.8	22.5	178	174.7	34.0	238	233.6	45.4	298	292.5	56.9
59	57.9	11.3	119	116.8	22.7	179	175.7	34.2	239	234.6	45.6	299	293.5	57.1
60	58.9	11.4	120	117.8	22.9	180	176.7	34.3	240	235.6	45.8	300	294.5	57.2
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Difference of Latitude and Departure for 12°.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	01.0	00.2	61	59.7	12.7	121	118.4	25.2	181	177.0	37.6	241	235.7	50.1
2	02.0	00.4	62	60.6	12.9	122	119.3	25.4	182	178.0	37.8	242	236.7	50.3
3	02.9	00.6	63	61.6	13.1	123	120.3	25.6	183	179.0	38.0	243	237.7	50.5
4	03.9	00.8	64	62.6	13.3	124	121.3	25.8	184	180.0	38.3	244	238.7	50.7
5	04.9	01.0	65	63.6	13.5	125	122.3	26.0	185	181.0	38.5	245	239.6	50.9
6	05.9	01.2	66	64.6	13.7	126	123.2	26.2	186	181.9	38.7	246	240.6	51.1
7	06.8	01.5	67	65.5	13.9	127	124.2	26.4	187	182.9	38.9	247	241.6	51.4
8	07.8	01.7	68	66.5	14.1	128	125.2	26.6	188	183.9	39.1	248	242.6	51.6
9	08.8	01.9	69	67.5	14.3	129	126.2	26.8	189	184.9	39.3	249	243.6	51.8
10	09.8	02.1	70	68.5	14.6	130	127.2	27.0	190	185.8	39.5	250	244.5	52.0
11	10.8	02.3	71	69.4	14.8	131	128.1	27.2	191	186.8	39.7	251	245.5	52.2
12	11.7	02.5	72	70.4	15.0	132	129.1	27.4	192	187.8	39.9	252	246.5	52.4
13	12.7	02.7	73	71.4	15.2	133	130.1	27.7	193	188.8	40.1	253	247.5	52.6
14	13.7	02.9	74	72.4	15.4	134	131.1	27.9	194	189.8	40.3	254	248.4	52.8
15	14.7	03.1	75	73.4	15.6	135	132.0	28.1	195	190.7	40.5	255	249.4	53.0
16	15.7	03.3	76	74.3	15.8	136	133.0	28.3	196	191.7	40.8	256	250.4	53.2
17	16.6	03.5	77	75.3	16.0	137	134.0	28.5	197	192.7	41.0	257	251.4	53.4
18	17.6	03.7	78	76.3	16.2	138	135.0	28.7	198	193.7	41.2	258	252.4	53.6
19	18.6	04.0	79	77.3	16.4	139	136.0	28.9	199	194.7	41.4	259	253.3	53.8
20	19.6	04.2	80	78.3	16.6	140	136.9	29.1	200	195.6	41.6	260	254.3	54.1
21	20.5	04.4	81	79.2	16.8	141	137.9	29.3	201	196.6	41.8	261	255.3	54.3
22	21.5	04.6	82	80.2	17.0	142	138.9	29.5	202	197.6	42.0	262	256.3	54.5
23	22.5	04.8	83	81.2	17.3	143	139.9	29.7	203	198.6	42.2	263	257.3	54.7
24	23.5	05.0	84	82.2	17.5	144	140.9	29.9	204	199.5	42.4	264	258.2	54.9
25	24.5	05.2	85	83.1	17.7	145	141.8	30.1	205	200.5	42.6	265	259.2	55.1
26	25.4	05.4	86	84.1	17.9	146	142.8	30.4	206	201.5	42.8	266	260.2	55.3
27	26.4	05.6	87	85.1	18.1	147	143.8	30.6	207	202.5	43.0	267	261.2	55.5
28	27.4	05.8	88	86.1	18.3	148	144.8	30.8	208	203.5	43.2	268	262.1	55.7
29	28.4	06.0	89	87.1	18.5	149	145.7	31.0	209	204.4	43.5	269	263.1	55.9
30	29.3	06.2	90	88.0	18.7	150	146.7	31.2	210	205.4	43.7	270	264.1	56.1
31	30.3	06.4	91	89.0	18.9	151	147.7	31.4	211	206.4	43.9	271	265.1	56.3
32	31.3	06.7	92	90.0	19.1	152	148.7	31.6	212	207.4	44.1	272	266.1	56.6
33	32.3	06.9	93	91.0	19.3	153	149.7	31.8	213	208.3	44.3	273	267.0	56.8
34	33.3	07.1	94	91.9	19.5	154	150.6	32.0	214	209.3	44.5	274	268.0	57.0
35	34.2	07.3	95	92.9	19.8	155	151.6	32.2	215	210.3	44.7	275	269.0	57.2
36	35.2	07.5	96	93.9	20.0	156	152.6	32.4	216	211.3	44.9	276	270.0	57.4
37	36.2	07.7	97	94.9	20.2	157	153.6	32.6	217	212.3	45.1	277	270.9	57.6
38	37.2	07.9	98	95.9	20.4	158	154.5	32.9	218	213.2	45.3	278	271.9	57.8
39	38.1	08.1	99	96.8	20.6	159	155.5	33.1	219	214.2	45.5	279	272.9	58.0
40	39.1	08.3	100	97.8	20.8	160	156.5	33.3	220	215.2	45.7	280	273.9	58.2
41	40.1	08.5	101	98.8	21.0	161	157.5	33.5	221	216.2	45.9	281	274.9	58.4
42	41.1	08.7	102	99.8	21.2	162	158.5	33.7	222	217.1	46.2	282	275.8	58.6
43	42.1	08.9	103	100.7	21.4	163	159.4	33.9	223	218.1	46.4	283	276.8	58.8
44	43.0	09.1	104	101.7	21.6	164	160.4	34.1	224	219.1	46.6	284	277.8	59.0
45	44.0	09.4	105	102.7	21.8	165	161.4	34.3	225	220.1	46.8	285	278.8	59.3
46	45.0	09.6	106	103.7	22.0	166	162.4	34.5	226	221.1	47.0	286	279.8	59.5
47	46.0	09.8	107	104.7	22.2	167	163.4	34.7	227	222.0	47.2	287	280.7	59.7
48	47.0	10.0	108	105.6	22.5	168	164.3	34.9	228	223.0	47.4	288	281.7	59.9
49	47.9	10.2	109	106.6	22.7	169	165.3	35.1	229	224.0	47.6	289	282.7	60.1
50	48.9	10.4	110	107.6	22.9	170	166.3	35.3	230	225.0	47.8	290	283.7	60.3
51	49.9	10.6	111	108.6	23.1	171	167.3	35.6	231	226.0	48.0	291	284.6	60.5
52	50.9	10.8	112	109.6	23.3	172	168.2	35.8	232	226.9	48.2	292	285.6	60.7
53	51.8	11.0	113	110.5	23.5	173	169.2	36.0	233	227.9	48.4	293	286.6	60.9
54	52.8	11.2	114	111.5	23.7	174	170.2	36.2	234	228.9	48.7	294	287.6	61.1
55	53.8	11.4	115	112.5	23.9	175	171.2	36.4	235	229.9	48.9	295	288.6	61.3
56	54.8	11.6	116	113.5	24.1	176	172.2	36.6	236	230.8	49.1	296	289.5	61.5
57	55.8	11.9	117	114.4	24.3	177	173.1	36.8	237	231.8	49.3	297	290.5	61.7
58	56.7	12.1	118	115.4	24.5	178	174.1	37.0	238	232.8	49.5	298	291.5	62.0
59	57.7	12.3	119	116.4	24.7	179	175.1	37.2	239	233.8	49.7	299	292.5	62.2
60	58.7	12.5	120	117.4	24.9	180	176.1	37.4	240	234.8	49.9	300	293.4	62.4
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Difference of Latitude and Departure for 13°.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	01.0	00.2	61	59.4	13.7	121	117.9	27.2	181	176.4	40.7	241	234.8	54.2
2	01.9	00.4	62	60.4	13.9	122	118.9	27.4	182	177.3	40.9	242	235.8	54.4
3	02.9	00.7	63	61.4	14.2	123	119.8	27.7	183	178.3	41.2	243	236.8	54.7
4	03.9	00.9	64	62.4	14.4	124	120.8	27.9	184	179.3	41.4	244	237.7	54.9
5	04.9	01.1	65	63.3	14.6	125	121.8	28.1	185	180.3	41.6	245	238.7	55.1
6	05.8	01.3	66	64.3	14.8	126	122.8	28.3	186	181.2	41.8	246	239.7	55.3
7	06.8	01.6	67	65.3	15.1	127	123.7	28.6	187	182.2	42.1	247	240.7	55.6
8	07.8	01.8	68	66.3	15.3	128	124.7	28.8	188	183.2	42.3	248	241.6	55.8
9	08.8	02.0	69	67.2	15.5	129	125.7	29.0	189	184.2	42.5	249	242.6	56.0
10	09.7	02.2	70	68.2	15.7	130	126.7	29.2	190	185.1	42.7	250	243.6	56.2
11	10.7	02.5	71	69.2	16.0	131	127.6	29.5	191	186.1	43.0	251	244.6	56.5
12	11.7	02.7	72	70.2	16.2	132	128.6	29.7	192	187.1	43.2	252	245.5	56.7
13	12.7	02.9	73	71.1	16.4	133	129.6	29.9	193	188.1	43.4	253	246.5	56.9
14	13.6	03.1	74	72.1	16.6	134	130.6	30.1	194	189.0	43.6	254	247.5	57.1
15	14.6	03.4	75	73.1	16.9	135	131.5	30.4	195	190.0	43.9	255	248.5	57.4
16	15.6	03.6	76	74.1	17.1	136	132.5	30.6	196	191.0	44.1	256	249.4	57.6
17	16.6	03.8	77	75.0	17.3	137	133.5	30.8	197	192.0	44.3	257	250.4	57.8
18	17.5	04.0	78	76.0	17.5	138	134.5	31.0	198	192.9	44.5	258	251.4	58.0
19	18.5	04.3	79	77.0	17.8	139	135.4	31.3	199	193.9	44.8	259	252.4	58.3
20	19.5	04.5	80	77.9	18.0	140	136.4	31.5	200	194.9	45.0	260	253.3	58.5
21	20.5	04.7	81	78.9	18.2	141	137.4	31.7	201	195.8	45.2	261	254.3	58.7
22	21.4	04.9	82	79.9	18.4	142	138.4	31.9	202	196.8	45.4	262	255.3	58.9
23	22.4	05.2	83	80.9	18.7	143	139.3	32.2	203	197.8	45.7	263	256.3	59.2
24	23.4	05.4	84	81.8	18.9	144	140.3	32.4	204	198.8	45.9	264	257.2	59.4
25	24.4	05.6	85	82.8	19.1	145	141.3	32.6	205	199.7	46.1	265	258.2	59.6
26	25.3	05.8	86	83.8	19.3	146	142.3	32.8	206	200.7	46.3	266	259.2	59.8
27	26.3	06.1	87	84.8	19.6	147	143.2	33.1	207	201.7	46.6	267	260.2	60.1
28	27.3	06.3	88	85.7	19.8	148	144.2	33.3	208	202.7	46.8	268	261.1	60.3
29	28.3	06.5	89	86.7	20.0	149	145.2	33.5	209	203.6	47.0	269	262.1	60.5
30	29.2	06.7	90	87.7	20.2	150	146.2	33.7	210	204.6	47.2	270	263.1	60.7
31	30.2	07.0	91	88.7	20.5	151	147.1	34.0	211	205.6	47.5	271	264.1	61.0
32	31.2	07.2	92	89.6	20.7	152	148.1	34.2	212	206.6	47.7	272	265.0	61.2
33	32.2	07.4	93	90.6	20.9	153	149.1	34.4	213	207.5	47.9	273	266.0	61.4
34	33.1	07.6	94	91.6	21.1	154	150.1	34.6	214	208.5	48.1	274	267.0	61.6
35	34.1	07.9	95	92.6	21.4	155	151.0	34.9	215	209.5	48.4	275	268.0	61.9
36	35.1	08.1	96	93.5	21.6	156	152.0	35.1	216	210.5	48.6	276	268.9	62.1
37	36.1	08.3	97	94.5	21.8	157	153.0	35.3	217	211.4	48.8	277	269.9	62.3
38	37.0	08.5	98	95.5	22.0	158	154.0	35.5	218	212.4	49.0	278	270.9	62.5
39	38.0	08.8	99	96.5	22.3	159	154.9	35.8	219	213.4	49.3	279	271.8	62.8
40	39.0	09.0	100	97.4	22.5	160	155.9	36.0	220	214.4	49.5	280	272.8	63.0
41	39.9	09.2	101	98.4	22.7	161	156.9	36.2	221	215.3	49.7	281	273.8	63.2
42	40.9	09.4	102	99.4	22.9	162	157.8	36.4	222	216.3	49.9	282	274.8	63.4
43	41.9	09.7	103	100.4	23.2	163	158.8	36.7	223	217.3	50.2	283	275.7	63.7
44	42.9	09.9	104	101.3	23.4	164	159.8	36.9	224	218.3	50.4	284	276.7	63.9
45	43.8	10.1	105	102.3	23.6	165	160.8	37.1	225	219.2	50.6	285	277.7	64.1
46	44.8	10.3	106	103.3	23.8	166	161.7	37.3	226	220.2	50.8	286	278.7	64.3
47	45.8	10.6	107	104.3	24.1	167	162.7	37.6	227	221.2	51.1	287	279.6	64.6
48	46.8	10.8	108	105.2	24.3	168	163.7	37.8	228	222.2	51.3	288	280.6	64.8
49	47.7	11.0	109	106.2	24.5	169	164.7	38.0	229	223.1	51.5	289	281.6	65.0
50	48.7	11.2	110	107.2	24.7	170	165.6	38.2	230	224.1	51.7	290	282.6	65.2
51	49.7	11.5	111	108.2	25.0	171	166.6	38.5	231	225.1	52.0	291	283.5	65.5
52	50.7	11.7	112	109.1	25.2	172	167.6	38.7	232	226.1	52.2	292	284.5	65.7
53	51.6	11.9	113	110.1	25.4	173	168.6	38.9	233	227.0	52.4	293	285.5	65.9
54	52.6	12.1	114	111.1	25.6	174	169.5	39.1	234	228.0	52.6	294	286.5	66.1
55	53.6	12.4	115	112.1	25.9	175	170.5	39.4	235	229.0	52.9	295	287.4	66.4
56	54.6	12.6	116	113.0	26.1	176	171.5	39.6	236	230.0	53.1	296	288.4	66.6
57	55.5	12.8	117	114.0	26.3	177	172.5	39.8	237	230.9	53.3	297	289.4	66.8
58	56.5	13.0	118	115.0	26 5	178	173.4	40.0	238	231.9	53.5	298	290.4	67.0
59	57.5	13.3	119	116.0	26.8	179	174.4	40.3	239	232.9	53.8	299	291.3	67.3
60	58.5	13.5	120	116.9	27.0	180	175.4	40.5	240	233.8	54.0	300	292.3	67.5
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Difference of Latitude and Departure for 14°.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	01.0	00.2	61	59.2	14.8	121	117.4	29.3	181	175.6	43.8	241	233.8	58.3
2	01.9	00.5	62	60.2	15.0	122	118.4	29.5	182	176.6	44.0	242	234.8	58.5
3	02.9	00.7	63	61.1	15.2	123	119.3	29.8	183	177.6	44.3	243	235.8	58.8
4	03.9	01.0	64	62.1	15.5	124	120.3	30.0	184	178.5	44.5	244	236.8	59.0
5	04.9	01.2	65	63.1	15.7	125	121.3	30.2	185	179.5	44.8	245	237.7	59.3
6	05.8	01.5	66	64.0	16.0	126	122.3	30.5	186	180.5	45.0	246	238.7	59.5
7	06.8	01.7	67	65.0	16.2	127	123.2	30.7	187	181.4	45.2	247	239.7	59.8
8	07.8	01.9	68	66.0	16.5	128	124.2	31.0	188	182.4	45.5	248	240.6	60.0
9	08.7	02.2	69	67.0	16.7	129	125.2	31.2	189	183.4	45.7	249	241.6	60.2
10	09.7	02.4	70	67.9	16.9	130	126.1	31.4	190	184.4	46.0	250	242.6	60.5
11	10.7	02.7	71	68.9	17.2	131	127.1	31.7	191	185.3	46.2	251	243.5	60.7
12	11.6	02.9	72	69.9	17.4	132	128.1	31.9	192	186.3	46.4	252	244.5	61.0
13	12.6	03.1	73	70.8	17.7	133	129.0	32.2	193	187.3	46.7	253	245.5	61.2
14	13.6	03.4	74	71.8	17.9	134	130.0	32.4	194	188.2	46.9	254	246.5	61.4
15	14.6	03.6	75	72.8	18.1	135	131.0	32.7	195	189.2	47.2	255	247.4	61.7
16	15.5	03.9	76	73.7	18.4	136	132.0	32.9	196	190.2	47.4	256	248.4	61.9
17	16.5	04.1	77	74.7	18.6	137	132.9	33.1	197	191.1	47.7	257	249.4	62.2
18	17.5	04.4	78	75.7	18.9	138	133.9	33.4	198	192.1	47.9	258	250.3	62.4
19	18.4	04.6	79	76.7	19.1	139	134.9	33.6	199	193.1	48.1	259	251.3	62.7
20	19.4	04.8	80	77.6	19.4	140	135.8	33.9	200	194.1	48.4	260	252.3	62.9
21	20.4	05.1	81	78.6	19.6	141	136.8	34.1	201	195.0	48.6	261	253.2	63.1
22	21.3	05.3	82	79.6	19.8	142	137.8	34.4	202	196.0	48.9	262	254.2	63.4
23	22.3	05.6	83	80.5	20.1	143	138.8	34.6	203	197.0	49.1	263	255.2	63.6
24	23.3	05.8	84	81.5	20.3	144	139.7	34.8	204	197.9	49.4	264	256.2	63.9
25	24.3	06.0	85	82.5	20.6	145	140.7	35.1	205	198.9	49.6	265	257.1	64.1
26	25.2	06.3	86	83.4	20.8	146	141.7	35.3	206	199.9	49.8	266	258.1	64.4
27	26.2	06.5	87	84.4	21.0	147	142.6	35.6	207	200.9	50.1	267	259.1	64.6
28	27.2	06.8	88	85.4	21.3	148	143.6	35.8	208	201.8	50.3	268	260.0	64.8
29	28.1	07.0	89	86.4	21.5	149	144.6	36.0	209	202.8	50.6	269	261.0	65.1
30	29.1	07.3	90	87.3	21.8	150	145.5	36.3	210	203.8	50.8	270	262.0	65.3
31	30.1	07.5	91	88.3	22.0	151	146.5	36.5	211	204.7	51.0	271	263.0	65.6
32	31.0	07.7	92	89.3	22.3	152	147.5	36.8	212	205.7	51.3	272	263.9	65.8
33	32.0	08.0	93	90.2	22.5	153	148.5	37.0	213	206.7	51.5	273	264.9	66.0
34	33.0	08.2	94	91.2	22.7	154	149.4	37.3	214	207.6	51.8	274	265.9	66.3
35	34.0	08.5	95	92.2	23.0	155	150.4	37.5	215	208.6	52.0	275	266.8	66.5
36	34.9	08.7	96	93.1	23.2	156	151.4	37.7	216	209.6	52.3	276	267.8	66.8
37	35.9	09.0	97	94.1	23.5	157	152.3	38.0	217	210.6	52.5	277	268.8	67.0
38	36.9	09.2	98	95.1	23.7	158	153.3	38.2	218	211.5	52.7	278	269.7	67.3
39	37.8	09.4	99	96.1	24.0	159	154.3	38.5	219	212.5	53.0	279	270.7	67.5
40	38.8	09.7	100	97.0	24.2	160	155.2	38.7	220	213.5	53.2	280	271.7	67.7
41	39.8	09.9	101	98.0	24.4	161	156.2	38.9	221	214.4	53.5	281	272.7	68.0
42	40.8	10.2	102	99.0	24.7	162	157.2	39.2	222	215.4	53.7	282	273.6	68.2
43	41.7	10.4	103	99.9	24.9	163	158.2	39.4	223	216.4	53.9	283	274.6	68.5
44	42.7	10.6	104	100.9	25.2	164	159.1	39.7	224	217.3	54.2	284	275.6	68.7
45	43.7	10.9	105	101.9	25.4	165	160.1	39.9	225	218.3	54.4	285	276.5	68.9
46	44.6	11.1	106	102.9	25.6	166	161.1	40.2	226	219.3	54.7	286	277.5	69.2
47	45.6	11.4	107	103.8	25.9	167	162.0	40.4	227	220.3	54.9	287	278.5	69.4
48	46.6	11.6	108	104.8	26.1	168	163.0	40.6	228	221.2	55.2	288	279.4	69.7
49	47.5	11.9	109	105.8	26.4	169	164.0	40.9	229	222.2	55.4	289	280.4	69.9
50	48.5	12.1	110	106.7	26.6	170	165.0	41.1	230	223.2	55.6	290	281.4	70.2
51	49.5	12.3	111	107.7	26.9	171	165.9	41.4	231	224.1	55.9	291	282.4	70.4
52	50.5	12.6	112	108.7	27.1	172	166.9	41.6	232	225.1	56.1	292	283.3	70.6
53	51.4	12.8	113	109.6	27.3	173	167.9	41.9	233	226.1	56.4	293	284.3	70.9
54	52.4	13.1	114	110.6	27.6	174	168.8	42.1	234	227.0	56.6	294	285.3	71.1
55	53.4	13.3	115	111.6	27.8	175	169.8	42.3	235	228.0	56.9	295	286.2	71.4
56	54.3	13.5	116	112.6	28.1	176	170.8	42.6	236	229.0	57.1	296	287.2	71.6
57	55.3	13.8	117	113.5	28.3	177	171.7	42.8	237	230.0	57.3	297	288.2	71.9
58	56.3	14.0	118	114.5	28.6	178	172.7	43.1	238	230.9	57.6	298	289.1	72.1
59	57.2	14.3	119	115.5	28.8	179	173.7	43.3	239	231.9	57.8	299	290.1	72.3
60	58.2	14.5	120	116.4	29.0	180	174.7	43.5	240	232.9	58.1	300	291.1	72.6
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Difference of Latitude and Departure for 15°.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	01.0	00.3	61	58.9	15.8	121	116.9	31.3	181	174.8	46.8	241	232.8	62.4
2	01.9	00.5	62	59.9	16.0	122	117.8	31.6	182	175.8	47.1	242	233.8	62.6
3	02.9	00.8	63	60.9	16.3	123	118.8	31.8	183	176.8	47.4	243	234.7	62.9
4	03.9	01.0	64	61.8	16.6	124	119.8	32.1	184	177.7	47.6	244	235.7	63.2
5	04.8	01.3	65	62.8	16.8	125	120.7	32.4	185	178.7	47.9	245	236.7	63.4
6	05.8	01.6	66	63.8	17.1	126	121.7	32.6	186	179.7	48.1	246	237.6	63.7
7	06.8	01.8	67	64.7	17.3	127	122.7	32.9	187	180.6	48.4	247	238.6	63.9
8	07.7	02.1	68	65.7	17.6	128	123.6	33.1	188	181.6	48.7	248	239.5	64.2
9	08.7	02.3	69	66.6	17.9	129	124.6	33.4	189	182.6	48.9	249	240.5	64.4
10	09.7	02.6	70	67.6	18.1	130	125.6	33.6	190	183.5	49.2	250	241.5	64.7
11	10.6	02.8	71	68.6	18.4	131	126.5	33.9	191	184.5	49.4	251	242.4	65.0
12	11.6	03.1	72	69.5	18.6	132	127.5	34.2	192	185.5	49.7	252	243.4	65.2
13	12.6	03.4	73	70.5	18.9	133	128.5	34.4	193	186.4	50.0	253	244.4	65.5
14	13.5	03.6	74	71.5	19.2	134	129.4	34.7	194	187.4	50.2	254	245.3	65.7
15	14.5	03.9	75	72.4	19.4	135	130.4	34.9	195	188.4	50.5	255	246.3	66.0
16	15.5	04.1	76	73.4	19.7	136	131.4	35.2	196	189.3	50.7	256	247.3	66.3
17	16.4	04.4	77	74.4	19.9	137	132.3	35.5	197	190.3	51.0	257	248.2	66.5
18	17.4	04.7	78	75.3	20.2	138	133.3	35.7	198	191.3	51.2	258	249.2	66.8
19	18.4	04.9	79	76.3	20.4	139	134.3	36.0	199	192.2	51.5	259	250.2	67.0
20	19.3	05.2	80	77.3	20.7	140	135.2	36.2	200	193.2	51.8	260	251.1	67.3
21	20.3	05.4	81	78.2	21.0	141	136.2	36.5	201	194.2	52.0	261	252.1	67.6
22	21.3	05.7	82	79.2	21.2	142	137.2	36.8	202	195.1	52.3	262	253.1	67.8
23	22.2	06.0	83	80.2	21.5	143	138.1	37.0	203	196.1	52.5	263	254.0	68.1
24	23.2	06.2	84	81.1	21.7	144	139.1	37.3	204	197.0	52.8	264	255.0	68.3
25	24.1	06.5	85	82.1	22.0	145	140.1	37.5	205	198.0	53.1	265	256.0	68.6
26	25.1	06.7	86	83.1	22.3	146	141.0	37.8	206	199.0	53.3	266	256.9	68.8
27	26.1	07.0	87	84.0	22.5	147	142.0	38.0	207	199.9	53.6	267	257.9	69.1
28	27.0	07.2	88	85.0	22.8	148	143.0	38.3	208	200.9	53.8	268	258.9	69.4
29	28.0	07.5	89	86.0	23.0	149	143.9	38.6	209	201.9	54.1	269	259.8	69.6
30	29.0	07.8	90	86.9	23.3	150	144.9	38.8	210	202.8	54.4	270	260.8	69.9
31	29.9	08.0	91	87.9	23.6	151	145.9	39.1	211	203.8	54.6	271	261.8	70.1
32	30.9	08.3	92	88.9	23.8	152	146.8	39.3	212	204.8	54.9	272	262.7	70.4
33	31.9	08.5	93	89.8	24.1	153	147.8	39.6	213	205.7	55.1	273	263.7	70.7
34	32.8	08.8	94	90.8	24.3	154	148.8	39.9	214	206.7	55.4	274	264.7	70.9
35	33.8	09.1	95	91.8	24.6	155	149.7	40.1	215	207.7	55.6	275	265.6	71.2
36	34.8	09.3	96	92.7	24.8	156	150.7	40.4	216	208.6	55.9	276	266.6	71.4
37	35.7	09.6	97	93.7	25.1	157	151.7	40.6	217	209.6	56.2	277	267.6	71.7
38	36.7	09.8	98	94.7	25.4	158	152.6	40.9	218	210.6	56.4	278	268.5	72.0
39	37.7	10.1	99	95.6	25.6	159	153.6	41.2	219	211.5	56.7	279	269.5	72.2
40	38.6	10.4	100	96.6	25.9	160	154.5	41.4	220	212.5	56.9	280	270.5	72.5
41	39.6	10.6	101	97.6	26.1	161	155.5	41.7	221	213.5	57.2	281	271.4	72.7
42	40.6	10.9	102	98.5	26.4	162	156.5	41.9	222	214.4	57.5	282	272.4	73.0
43	41.5	11.1	103	99.5	26.7	163	157.4	42.2	223	215.4	57.7	283	273.4	73.2
44	42.5	11.4	104	100.5	26.9	164	158.4	42.4	224	216.4	58.0	284	274.3	73.5
45	43.5	11.6	105	101.4	27.2	165	159.4	42.7	225	217.3	58.2	285	275.3	73.8
46	44.4	11.9	106	102.4	27.4	166	160.3	43.0	226	218.3	58.5	286	276.3	74.0
47	45.4	12.2	107	103.4	27.7	167	161.3	43.2	227	219.3	58.8	287	277.2	74.3
48	46.4	12.4	108	104.3	28.0	168	162.3	43.5	228	220.2	59.0	288	278.2	74.5
49	47.3	12.7	109	105.3	28.2	169	163.2	43.7	229	221.2	59.3	289	279.2	74.8
50	48.3	12.9	110	106.3	28.5	170	164.2	44.0	230	222.2	59.5	290	280.1	75.1
51	49.3	13.2	111	107.2	28.7	171	165.2	44.3	231	223.1	59.8	291	281.1	75.3
52	50.2	13.5	112	108.2	29.0	172	166.1	44.5	232	224.1	60.0	292	282.1	75.6
53	51.2	13.7	113	109.1	29.2	173	167.1	44.8	233	225.1	60.3	293	283.0	75.8
54	52.2	14.0	114	110.1	29.5	174	168.1	45.0	234	226.0	60.6	294	284.0	76.1
55	53.1	14.2	115	111.1	29.8	175	169.0	45.3	235	227.0	60.8	295	284.9	76.4
56	54.1	14.5	116	112.0	30.0	176	170.0	45.6	236	228.0	61.1	296	285.9	76.6
57	55.1	14.8	117	113.0	30.3	177	171.0	45.8	237	228.9	61.3	297	286.9	76.9
58	56.0	15.0	118	114.0	30.5	178	171.9	46.1	238	229.9	61.6	298	287.8	77.1
59	57.0	15.3	119	114.9	30.8	179	172.9	46.3	239	230.9	61.9	299	288.8	77.4
60	58.0	15.5	120	115.9	31.1	180	173.9	46.6	240	231.8	62.1	300	289.8	77.6
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Difference of Latitude and Departure for 16°.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist	Lat.	Dep.
1	01.0	00.3	61	58.6	16.8	121	116.3	33.4	181	174.0	49.9	241	231.7	66.4
2	01.9	00.6	62	59.6	17.1	122	117.3	33.6	182	174.9	50.2	242	232.6	66.7
3	02.9	00.8	63	60.6	17.4	123	118.2	33.9	183	175.9	50.4	243	233.6	67.0
4	03.8	01.1	64	61.5	17.6	124	119.2	34.2	184	176.9	50.7	244	234.5	67.3
5	04.8	01.4	65	62.5	17.9	125	120.2	34.5	185	177.8	51.0	245	235.5	67.5
6	05.8	01.7	66	63.4	18.2	126	121.1	34.7	186	178.8	51.3	246	236.5	67.8
7	06.7	01.9	67	64.4	18.5	127	122.1	35.0	187	179.8	51.5	247	237.4	68.1
8	07.7	02.2	68	65.4	18.7	128	123.0	35.3	188	180.7	51.8	248	238.4	68.4
9	08.7	02.5	69	66.3	19.0	129	124.0	35.6	189	181.7	52.1	249	239.4	68.6
10	09.6	02.8	70	67.3	19.3	130	125.0	35.8	190	182.6	52.4	250	240.3	68.9
11	10.6	03.0	71	68.2	19.6	131	125.9	36.1	191	183.6	52.6	251	241.3	69.2
12	11.5	03.3	72	69.2	19.8	132	126.9	36.4	192	184.6	52.9	252	242.2	69.5
13	12.5	03.6	73	70.2	20.1	133	127.8	36.7	193	185.5	53.2	253	243.2	69.7
14	13.5	03.9	74	71.1	20.4	134	128.8	36.9	194	186.5	53.5	254	244.2	70.0
15	14.4	04.1	75	72.1	20.7	135	129.8	37.2	195	187.4	53.7	255	245.1	70.3
16	15.4	04.4	76	73.1	20.9	136	130.7	37.5	196	188.4	54.0	256	246.1	70.6
17	16.3	04.7	77	74.0	21.2	137	131.7	37.8	197	189.4	54.3	257	247.0	70.8
18	17.3	05.0	78	75.0	21.5	138	132.7	38.0	198	190.3	54.6	258	248.0	71.1
19	18.3	05.2	79	75.9	21.8	139	133.6	38.3	199	191.3	54.9	259	249.0	71.4
20	19.2	05.5	80	76.9	22.1	140	134.6	38.6	200	192.3	55.1	260	249.9	71.7
21	20.2	05.8	81	77.9	22.3	141	135.5	38.9	201	193.2	55.4	261	250.9	71.9
22	21.1	06.1	82	78.8	22.6	142	136.5	39.1	202	194.2	55.7	262	251.9	72.2
23	22.1	06.3	83	79.8	22.9	143	137.5	39.4	203	195.1	56.0	263	252.8	72.5
24	23.1	06.6	84	80.7	23.2	144	138.4	39.7	204	196.1	56.2	264	253.8	72.8
25	24.0	06.9	85	81.7	23.4	145	139.4	40.0	205	197.1	56.5	265	254.7	73.0
26	25.0	07.2	86	82.7	23.7	146	140.3	40.2	206	198.0	56.8	266	255.7	73.3
27	26.0	07.4	87	83.6	24.0	147	141.3	40.5	207	199.0	57.1	267	256.7	73.6
28	26.9	07.7	88	84.6	24.3	148	142.3	40.8	208	199.9	57.3	268	257.6	73.9
29	27.9	08.0	89	85.6	24.5	149	143.2	41.1	209	200.9	57.6	269	258.6	74.1
30	28.8	08.3	90	86.5	24.8	150	144.2	41.3	210	201.9	57.9	270	259.5	74.4
31	29.8	08.5	91	87.5	25.1	151	145.2	41.6	211	202.8	58.2	271	260.5	74.7
32	30.8	08.8	92	88.4	25.4	152	146.1	41.9	212	203.8	58.4	272	261.5	75.0
33	31.7	09.1	93	89.4	25.6	153	147.1	42.2	213	204.7	58.7	273	262.4	75.2
34	32.7	09.4	94	90.4	25.9	154	148.0	42.4	214	205.7	59.0	274	263.4	75.5
35	33.6	09.6	95	91.3	26.2	155	149.0	42.7	215	206.7	59.3	275	264.3	75.8
36	34.6	09.9	96	92.3	26.5	156	150.0	43.0	216	207.6	59.5	276	265.3	76.1
37	35.6	10.2	97	93.2	26.7	157	150.9	43.3	217	208.6	59.8	277	266.3	76.4
38	36.5	10.5	98	94.2	27.0	158	151.9	43.6	218	209.6	60.1	278	267.2	76.6
39	37.5	10.7	99	95.2	27.3	159	152.8	43.8	219	210.5	60.4	279	268.2	76.9
40	38.5	11.0	100	96.1	27.6	160	153.8	44.1	220	211.5	60.6	280	269.2	77.2
41	39.4	11.3	101	97.1	27.8	161	154.8	44.4	221	212.4	60.9	281	270.1	77.5
42	40.4	11.6	102	98.0	28.1	162	155.7	44.7	222	213.4	61.2	282	271.1	77.7
43	41.3	11.9	103	99.0	28.4	163	156.7	44.9	223	214.4	61.5	283	272.0	78.0
44	42.3	12.1	104	100.0	28.7	164	157.6	45.2	224	215.3	61.7	284	273.0	78.3
45	43.3	12.4	105	100.9	28.9	165	158.6	45.5	225	216.3	62.0	285	274.0	78.6
46	44.2	12.7	106	101.9	29.2	166	159.6	45.8	226	217.2	62.3	286	274.9	78.8
47	45.2	13.0	107	102.9	29.5	167	160.5	46.0	227	218.2	62.6	287	275.9	79.1
48	46.1	13.2	108	103.8	29.8	168	161.5	46.3	228	219.2	62.8	288	276.8	79.4
49	47.1	13.5	109	104.8	30.0	169	162.5	46.6	229	220.1	63.1	289	277.8	79.7
50	48.1	13.8	110	105.7	30.3	170	163.4	46.9	230	221.1	63.4	290	278.8	79.9
51	49.0	14.1	111	106.7	30.6	171	164.4	47.1	231	222.1	63.7	291	279.7	80.2
52	50.0	14.3	112	107.7	30.9	172	165.3	47.4	232	223.0	63.9	292	280.7	80.5
53	50.9	14.6	113	108.6	31.1	173	166.3	47.7	233	224.0	64.2	293	281.6	80.8
54	51.9	14.9	114	109.6	31.4	174	167.3	48.0	234	224.9	64.5	294	282.6	81.0
55	52.9	15.2	115	110.5	31.7	175	168.2	48.2	235	225.9	64.8	295	283.6	81.3
56	53.8	15.4	116	111.5	32.0	176	169.2	48.5	236	226.9	65.1	296	284.5	81.6
57	54.8	15.7	117	112.5	32.2	177	170.1	48.8	237	227.8	65.3	297	285.5	81.9
58	55.8	16.0	118	113.4	32.5	178	171.1	49.1	238	228.8	65.6	298	286.5	82.1
59	56.7	16.3	119	114.4	32.8	179	172.1	49.3	239	229.7	65.9	299	287.4	82.4
60	57.7	16.5	120	115.4	33.1	180	173.0	49.6	240	230.7	66.2	300	288.4	82.7
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Difference of Latitude and Departure for 17°.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	01.0	00.3	61	58.3	17.8	121	115.7	35.4	181	173.1	52.9	241	230.5	70.5
2	01.9	00.6	62	59.3	18.1	122	116.7	35.7	182	174.0	53.2	242	231.4	70.8
3	02.9	00.9	63	60.2	18.4	123	117.6	36.0	183	175.0	53.5	243	232.4	71.0
4	03.8	01.2	64	61.2	18.7	124	118.6	36.3	184	176.0	53.8	244	233.3	71.3
5	04.8	01.5	65	62.2	19.0	125	119.5	36.5	185	176.9	54.1	245	234.3	71.6
6	05.7	01.8	66	63.1	19.3	126	120.5	36.8	186	177.9	54.4	246	235.3	71.9
7	06.7	02.0	67	64.1	19.6	127	121.5	37.1	187	178.8	54.7	247	236.2	72.2
8	07.7	02.3	68	65.0	19.9	128	122.4	37.4	188	179.8	55.0	248	237.2	72.5
9	08.6	02.6	69	66.0	20.2	129	123.4	37.7	189	180.7	55.3	249	238.1	72.8
10	09.6	02.9	70	66.9	20.5	130	124.3	38.0	190	181.7	55.6	250	239.1	73.1
11	10.5	03.2	71	67.9	20.8	131	125.3	38.3	191	182.7	55.8	251	240.0	73.4
12	11.5	03.5	72	68.9	21.1	132	126.2	38.6	192	183.6	56.1	252	241.0	73.7
13	12.4	03.8	73	69.8	21.3	133	127.2	38.9	193	184.6	56.4	253	241.9	74.0
14	13.4	04.1	74	70.8	21.6	134	128.1	39.2	194	185.5	56.7	254	242.9	74.3
15	14.3	04.4	75	71.7	21.9	135	129.1	39.5	195	186.5	57.0	255	243.9	74.6
16	15.3	04.7	76	72.7	22.2	136	130.1	39.8	196	187.4	57.3	256	244.8	74.8
17	16.3	05.0	77	73.6	22.5	137	131.0	40.1	197	188.4	57.6	257	245.8	75.1
18	17.2	05.3	78	74.6	22.8	138	132.0	40.3	198	189.3	57.9	258	246.7	75.4
19	18.2	05.6	79	75.5	23.1	139	132.9	40.6	199	190.3	58.2	259	247.7	75.7
20	19.1	05.8	80	76.5	23.4	140	133.9	40.9	200	191.3	58.5	260	248.6	76.0
21	20.1	06.1	81	77.5	23.7	141	134.8	41.2	201	192.2	58.8	261	249.6	76.3
22	21.0	06.4	82	78.4	24.0	142	135.8	41.5	202	193.2	59.1	262	250.6	76.6
23	22.0	06.7	83	79.4	24.3	143	136.8	41.8	203	194.1	59.4	263	251.5	76.9
24	23.0	07.0	84	80.3	24.6	144	137.7	42.1	204	195.1	59.6	264	252.5	77.2
25	23.9	07.3	85	81.3	24.9	145	138.7	42.4	205	196.0	59.9	265	253.4	77.5
26	24.9	07.6	86	82.2	25.1	146	139.6	42.7	206	197.0	60.2	266	254.4	77.8
27	25.8	07.9	87	83.2	25.4	147	140.6	43.0	207	198.0	60.5	267	255.3	78.1
28	26.8	08.2	88	84.2	25.7	148	141.5	43.3	208	198.9	60.8	268	256.3	78.4
29	27.7	08.5	89	85.1	26.0	149	142.5	43.6	209	199.9	61.1	269	257.2	78.6
30	28.7	08.8	90	86.1	26.3	150	143.4	43.9	210	200.8	61.4	270	258.2	78.9
31	29.6	09.1	91	87.0	26.6	151	144.4	44.1	211	201.8	61.7	271	259.2	79.2
32	30.6	09.4	92	88.0	26.9	152	145.4	44.4	212	202.7	62.0	272	260.1	79.5
33	31.6	09.6	93	88.9	27.2	153	146.3	44.7	213	203.7	62.3	273	261.1	79.8
34	32.5	09.9	94	89.9	27.5	154	147.3	45.0	214	204.6	62.6	274	262.0	80.1
35	33.5	10.2	95	90.8	27.8	155	148.2	45.3	215	205.6	62.9	275	263.0	80.4
36	34.4	10.5	96	91.8	28.1	156	149.2	45.6	216	206.6	63.2	276	263.9	80.7
37	35.4	10.8	97	92.8	28.4	157	150.1	45.9	217	207.5	63.4	277	264.9	81.0
38	36.3	11.1	98	93.7	28.7	158	151.1	46.2	218	208.5	63.7	278	265.9	81.3
39	37.3	11.4	99	94.7	28.9	159	152.1	46.5	219	209.4	64.0	279	266.8	81.6
40	38.3	11.7	100	95.6	29.2	160	153.0	46.8	220	210.4	64.3	280	267.8	81.9
41	39.2	12.0	101	96.6	29.5	161	154.0	47.1	221	211.3	64.6	281	268.7	82.2
42	40.2	12.3	102	97.5	29.8	162	154.9	47.4	222	212.3	64.9	282	269.7	82.4
43	41.1	12.6	103	98.5	30.1	163	155.9	47.7	223	213.3	65.2	283	270.6	82.7
44	42.1	12.9	104	99.5	30.4	164	156.8	47.9	224	214.2	65.5	284	271.6	83.0
45	43.0	13.2	105	100.4	30.7	165	157.8	48.2	225	215.2	65.8	285	272.5	83.3
46	44.0	13.4	106	101.4	31.0	166	158.7	48.5	226	216.1	66.1	286	273.5	83.6
47	44.9	13.7	107	102.3	31.3	167	159.7	48.8	227	217.1	66.4	287	274.5	83.9
48	45.9	14.0	108	103.3	31.6	168	160.7	49.1	228	218.0	66.7	288	275.4	84.2
49	46.9	14.3	109	104.2	31.9	169	161.6	49.4	229	219.0	67.0	289	276.4	84.5
50	47.8	14.6	110	105.2	32.2	170	162.6	49.7	230	220.0	67.2	290	277.3	84.8
51	48.8	14.9	111	106.1	32.5	171	163.5	50.0	231	220.9	67.5	291	278.3	85.1
52	49.7	15.2	112	107.1	32.7	172	164.5	50.3	232	221.9	67.8	292	279.2	85.4
53	50.7	15.5	113	108.1	33.0	173	165.4	50.6	233	222.8	68.1	293	280.2	85.7
54	51.6	15.8	114	109.0	33.3	174	166.4	50.9	234	223.8	68.4	294	281.2	86.0
55	52.6	16.1	115	110.0	33.6	175	167.4	51.2	235	224.7	68.7	295	282.1	86.2
56	53.6	16.4	116	110.9	33.9	176	168.3	51.5	236	225.7	69.0	296	283.1	86.5
57	54.5	16.7	117	111.9	34.2	177	169.3	51.7	237	226.6	69.3	297	284.0	86.8
58	55.5	17.0	118	112.8	34.5	178	170.2	52.0	238	227.6	69.6	298	285.0	87.1
59	56.4	17.2	119	113.8	34.8	179	171.2	52.3	239	228.6	69.9	299	285.9	87.4
60	57.4	17.5	120	114.8	35.1	180	172.1	52.6	240	229.5	70.2	300	286.9	87.7
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Difference of Latitude and Departure for 18°.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	01.0	00.3	61	58.0	18.9	121	115.1	37.4	181	172.1	55.9	241	229.2	74.5
2	01.9	00.6	62	59.0	19.2	122	116.0	37.7	182	173.1	56.2	242	230.2	74.8
3	02.9	00.9	63	59.9	19.5	123	117.0	38.0	183	174.0	56.6	243	231.1	75.1
4	03.8	01.2	64	60.9	19.8	124	117.9	38.3	184	175.0	56.9	244	232.1	75.4
5	04.8	01.5	65	61.8	20.1	125	118.9	38.6	185	175.9	57.2	245	233.0	75.7
6	05.7	01.9	66	62.8	20.4	126	119.8	38.9	186	176.9	57.5	246	234.0	76.0
7	06.7	02.2	67	63.7	20.7	127	120.8	39.2	187	177.8	57.8	247	234.9	76.3
8	07.6	02.5	68	64.7	21.0	128	121.7	39.6	188	178.8	58.1	248	235.9	76.6
9	08.6	02.8	69	65.6	21.3	129	122.7	39.9	189	179.7	58.4	249	236.8	76.9
10	09.5	03.1	70	66.6	21.6	130	123.6	40.2	190	180.7	58.7	250	237.8	77.3
11	10.5	03.4	71	67.5	21.9	131	124.6	40.5	191	181.7	59.0	251	238.7	77.6
12	11.4	03.7	72	68.5	22.2	132	125.5	40.8	192	182.6	59.3	252	239.7	77.9
13	12.4	04.0	73	69.4	22.6	133	126.5	41.1	193	183.6	59.6	253	240.6	78.2
14	13.3	04.3	74	70.4	22.9	134	127.4	41.4	194	184.5	59.9	254	241.6	78.5
15	14.3	04.6	75	71.3	23.2	135	128.4	41.7	195	185.5	60.3	255	242.5	78.8
16	15.2	04.9	76	72.3	23.5	136	129.3	42.0	196	186.4	60.6	256	243.5	79.1
17	16.2	05.3	77	73.2	23.8	137	130.3	42.3	197	187.4	60.9	257	244.4	79.4
18	17.1	05.6	78	74.2	24.1	138	131.2	42.6	198	188.3	61.2	258	245.4	79.7
19	18.1	05.9	79	75.1	24.4	139	132.2	43.0	199	189.3	61.5	259	246.3	80.0
20	19.0	06.2	80	76.1	24.7	140	133.1	43.3	200	190.2	61.8	260	247.3	80.3
21	20.0	06.5	81	77.0	25.0	141	134.1	43.6	201	191.2	62.1	261	248.2	80.7
22	20.9	06.8	82	78.0	25.3	142	135.1	43.9	202	192.1	62.4	262	249.2	81.0
23	21.9	07.1	83	78.9	25.6	143	136.0	44.2	203	193.1	62.7	263	250.1	81.3
24	22.8	07.4	84	79.9	26.0	144	137.0	44.5	204	194.0	63.0	264	251.1	81.6
25	23.8	07.7	85	80.8	26.3	145	137.9	44.8	205	195.0	63.3	265	252.0	81.9
26	24.7	08.0	86	81.8	26.6	146	138.9	45.1	206	195.9	63.7	266	253.0	82.2
27	25.7	08.3	87	82.7	26.9	147	139.8	45.4	207	196.9	64.0	267	253.9	82.5
28	26.6	08.7	88	83.7	27.2	148	140.8	45.7	208	197.8	64.3	268	254.9	82.8
29	27.6	09.0	89	84.6	27.5	149	141.7	46.0	209	198.8	64.6	269	255.8	83.1
30	28.5	09.3	90	85.6	27.8	150	142.7	46.4	210	199.7	64.9	270	256.8	83.4
31	29.5	09.6	91	86.5	28.1	151	143.6	46.7	211	200.7	65.2	271	257.7	83.7
32	30.4	09.9	92	87.5	28.4	152	144.6	47.0	212	201.6	65.5	272	258.7	84.1
33	31.4	10.2	93	88.4	28.7	153	145.5	47.3	213	202.6	65.8	273	259.6	84.4
34	32.3	10.5	94	89.4	29.0	154	146.5	47.6	214	203.5	66.1	274	260.6	84.7
35	33.3	10.8	95	90.4	29.4	155	147.4	47.9	215	204.5	66.4	275	261.5	85.0
36	34.2	11.1	96	91.3	29.7	156	148.4	48.2	216	205.4	66.7	276	262.5	85.3
37	35.2	11.4	97	92.3	30.0	157	149.3	48.5	217	206.4	67.1	277	263.4	85.6
38	36.1	11.7	98	93.2	30.3	158	150.3	48.8	218	207.3	67.4	278	264.4	85.9
39	37.1	12.1	99	94.2	30.6	159	151.2	49.1	219	208.3	67.7	279	265.3	86.2
40	38.0	12.4	100	95.1	30.9	160	152.2	49.4	220	209.2	68.0	280	266.3	86.5
41	39.0	12.7	101	96.1	31.2	161	153.1	49.8	221	210.2	68.3	281	267.2	86.8
42	39.9	13.0	102	97.0	31.5	162	154.1	50.1	222	211.1	68.6	282	268.2	87.1
43	40.9	13.3	103	98.0	31.8	163	155.0	50.4	223	212.1	68.9	283	269.1	87.5
44	41.8	13.6	104	98.9	32.1	164	156.0	50.7	224	213.0	69.2	284	270.1	87.8
45	42.8	13.9	105	99.9	32.4	165	156.9	51.0	225	214.0	69.5	285	271.1	88.1
46	43.7	14.2	106	100.8	32.8	166	157.9	51.3	226	214.9	69.8	286	272.0	88.4
47	44.7	14.5	107	101.8	33.1	167	158.8	51.6	227	215.9	70.1	287	273.0	88.7
48	45.7	14.8	108	102.7	33.4	168	159.8	51.9	228	216.8	70.5	288	273.9	89.0
49	46.6	15.1	109	103.7	33.7	169	160.7	52.2	229	217.8	70.8	289	274.9	89.3
50	47.6	15.5	110	104.6	34.0	170	161.7	52.5	230	218.7	71.1	290	275.8	89.6
51	48.5	15.8	111	105.6	34.3	171	162.6	52.8	231	219.7	71.4	291	276.8	89.9
52	49.5	16.1	112	106.5	34.6	172	163.6	53.2	232	220.6	71.7	292	277.7	90.2
53	50.4	16.4	113	107.5	34.9	173	164.5	53.5	233	221.6	72.0	293	278.7	90.5
54	51.4	16.7	114	108.4	35.2	174	165.5	53.8	234	222.5	72.3	294	279.6	90.9
55	52.3	17.0	115	109.4	35.5	175	166.4	54.1	235	223.5	72.6	295	280.6	91.2
56	53.3	17.3	116	110.3	35.8	176	167.4	54.4	236	224.4	72.9	296	281.5	91.5
57	54.2	17.6	117	111.3	36.2	177	168.3	54.7	237	225.4	73.2	297	282.5	91.8
58	55.2	17.9	118	112.2	36.5	178	169.3	55.0	238	226.4	73.5	298	283.4	92.1
59	56.1	18.2	119	113.2	36.8	179	170.2	55.3	239	227.3	73.9	299	284.4	92.4
60	57.1	18.5	120	114.1	37.1	180	171.2	55.6	240	228.3	74.2	300	285.3	92.7
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Difference of Latitude and Departure for 19°.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.9	00.3	61	57.7	19.9	121	114.4	39.4	181	171.1	58.9	241	227.9	78.5
2	01.9	00.7	62	58.6	20.2	122	115.4	39.7	182	172.1	59.3	242	228.8	78.8
3	02.8	01.0	63	59.6	20.5	123	116.3	40.0	183	173.0	59.6	243	229.8	79.1
4	03.8	01.3	64	60.5	20.8	124	117.2	40.4	184	174.0	59.9	244	230.7	79.4
5	04.7	01.6	65	61.5	21.2	125	118.2	40.7	185	174.9	60.2	245	231.7	79.8
6	05.7	02.0	66	62.4	21.5	126	119.1	41.0	186	175.9	60.6	246	232.6	80.1
7	06.6	02.3	67	63.3	21.8	127	120.1	41.3	187	176.8	60.9	247	233.5	80.4
8	07.6	02.6	68	64.3	22.1	128	121.0	41.7	188	177.8	61.2	248	234.5	80.7
9	08.5	02.9	69	65.2	22.5	129	122.0	42.0	189	178.7	61.5	249	235.4	81.1
10	09.5	03.3	70	66.2	22.8	130	122.9	42.3	190	179.6	61.9	250	236.4	81.4
11	10.4	03.6	71	67.1	23.1	131	123.9	42.6	191	180.6	62.2	251	237.3	81.7
12	11.3	03.9	72	68.1	23.4	132	124.8	43.0	192	181.5	62.5	252	238.3	82.0
13	12.3	04.2	73	69.0	23.8	133	125.8	43.3	193	182.5	62.8	253	239.2	82.4
14	13.2	04.6	74	70.0	24.1	134	126.7	43.6	194	183.4	63.2	254	240.2	82.7
15	14.2	04.9	75	70.9	24.4	135	127.6	44.0	195	184.4	63.5	255	241.1	83.0
16	15.1	05.2	76	71.9	24.7	136	128.6	44.3	196	185.3	63.8	256	242.1	83.3
17	16.1	05.5	77	72.8	25.1	137	129.5	44.6	197	186.3	64.1	257	243.0	83.7
18	17.0	05.9	78	73.8	25.4	138	130.5	44.9	198	187.2	64.5	258	243.9	84.0
19	18.0	06.2	79	74.7	25.7	139	131.4	45.3	199	188.2	64.8	259	244.9	84.3
20	18.9	06.5	80	75.6	26.0	140	132.4	45.6	200	189.1	65.1	260	245.8	84.6
21	19.9	06.8	81	76.6	26.4	141	133.3	45.9	201	190.0	65.4	261	246.8	85.0
22	20.8	07.2	82	77.5	26.7	142	134.3	46.2	202	191.0	65.8	262	247.7	85.3
23	21.7	07.5	83	78.5	27.0	143	135.2	46.6	203	191.9	66.1	263	248.7	85.6
24	22.7	07.8	84	79.4	27.3	144	136.2	46.9	204	192.9	66.4	264	249.6	86.0
25	23.6	08.1	85	80.4	27.7	145	137.1	47.2	205	193.8	66.7	265	250.6	86.3
26	24.6	08.5	86	81.3	28.0	146	138.0	47.5	206	194.8	67.1	266	251.5	86.6
27	25.5	08.8	87	82.3	28.3	147	139.0	47.9	207	195.7	67.4	267	252.5	86.9
28	26.5	09.1	88	83.2	28.7	148	139.9	48.2	208	196.7	67.7	268	253.4	87.3
29	27.4	09.4	89	84.2	29.0	149	140.9	48.5	209	197.6	68.0	269	254.3	87.6
30	28.4	09.8	90	85.1	29.3	150	141.8	48.8	210	198.6	68.4	270	255.3	87.9
31	29.3	10.1	91	86.0	29.6	151	142.8	49.2	211	199.5	68.7	271	256.2	88.2
32	30.3	10.4	92	87.0	30.0	152	143.7	49.5	212	200.4	69.0	272	257.2	88.6
33	31.2	10.7	93	87.9	30.3	153	144.7	49.8	213	201.4	69.3	273	258.1	88.9
34	32.1	11.1	94	88.9	30.6	154	145.6	50.1	214	202.3	69.7	274	259.1	89.2
35	33.1	11.4	95	89.8	30.9	155	146.6	50.5	215	203.3	70.0	275	260.0	89.5
36	34.0	11.7	96	90.8	31.3	156	147.5	50.8	216	204.2	70.3	276	261.0	89.9
37	35.0	12.0	97	91.7	31.6	157	148.4	51.1	217	205.2	70.6	277	261.9	90.2
38	35.9	12.4	98	92.7	31.9	158	149.4	51.4	218	206.1	71.0	278	262.9	90.5
39	36.9	12.7	99	93.6	32.2	159	150.3	51.8	219	207.1	71.3	279	263.8	90.8
40	37.8	13.0	100	94.6	32.6	160	151.3	52.1	220	208.0	71.6	280	264.7	91.2
41	38.8	13.3	101	95.5	32.9	161	152.2	52.4	221	209.0	72.0	281	265.7	91.5
42	39.7	13.7	102	96.4	33.2	162	153.2	52.7	222	209.9	72.3	282	266.6	91.8
43	40.7	14.0	103	97.4	33.5	163	154.1	53.1	223	210.9	72.6	283	267.6	92.1
44	41.6	14.3	104	98.3	33.9	164	155.1	53.4	224	211.8	72.9	284	268.5	92.5
45	42.5	14.7	105	99.3	34.2	165	156.0	53.7	225	212.7	73.3	285	269.5	92.8
46	43.5	15.0	106	100.2	34.5	166	157.0	54.0	226	213.7	73.6	286	270.4	93.1
47	44.4	15.3	107	101.2	34.8	167	157.9	54.4	227	214.6	73.9	287	271.4	93.4
48	45.4	15.6	108	102.1	35.2	168	158.8	54.7	228	215.6	74.2	288	272.3	93.8
49	46.3	16.0	109	103.1	35.5	169	159.8	55.0	229	216.5	74.6	289	273.3	94.1
50	47.3	16.3	110	104.0	35.8	170	160.7	55.3	230	217.5	74.9	290	274.2	94.4
51	48.2	16.6	111	105.0	36.1	171	161.7	55.7	231	218.4	75.2	291	275.1	94.7
52	49.2	16.9	112	105.9	36.5	172	162.6	56.0	232	219.4	75.5	292	276.1	95.1
53	50.1	17.3	113	106.8	36.8	173	163.6	56.3	233	220.3	75.9	293	277.0	95.4
54	51.1	17.6	114	107.8	37.1	174	164.5	56.6	234	221.3	76.2	294	278.0	95.7
55	52.0	17.9	115	108.7	37.4	175	165.5	57.0	235	222.2	76.5	295	278.9	96.0
56	52.9	18.2	116	109.7	37.8	176	166.4	57.3	236	223.1	76.8	296	279.9	96.4
57	53.9	18.6	117	110.6	38.1	177	167.4	57.6	237	224.1	77.2	297	280.8	96.7
58	54.8	18.9	118	111.6	38.4	178	168.3	58.0	238	225.0	77.5	298	281.8	97.0
59	55.8	19.2	119	112.5	38.7	179	169.2	58.3	239	226.0	77.8	299	282.7	97.3
60	56.7	19.5	120	113.5	39.1	180	170.2	58.6	240	226.9	78.1	300	283.7	97.7
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Difference of Latitude and Departure for 20°.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.9	00.3	61	57.3	20.9	121	113.7	41.4	181	170.1	61.9	241	226.5	82.4
2	01.9	00.7	62	58.3	21.2	122	114.6	41.7	182	171.0	62.2	242	227.4	82.8
3	02.8	01.0	63	59.2	21.5	123	115.6	42.1	183	172.0	62.6	243	228.3	83.1
4	03.8	01.4	64	60.1	21.9	124	116.5	42.4	184	172.9	62.9	244	229.3	83.5
5	04.7	01.7	65	61.1	22.2	125	117.5	42.8	185	173.8	63.3	245	230.2	83.8
6	05.6	02.1	66	62.0	22.6	126	118.4	43.1	186	174.8	63.6	246	231.2	84.1
7	06.6	02.4	67	63.0	22.9	127	119.3	43.4	187	175.7	64.0	247	232.1	84.5
8	07.5	02.7	68	63.9	23.3	128	120.3	43.8	188	176.7	64.3	248	233.0	84.8
9	08.5	03.1	69	64.8	23.6	129	121.2	44.1	189	177.6	64.6	249	234.0	85.2
10	09.4	03.4	70	65.8	23.9	130	122.2	44.5	190	178.5	65.0	250	234.9	85.5
11	10.3	03.8	71	66.7	24.3	131	123.1	44.8	191	179.5	65.3	251	235.9	85.8
12	11.3	04.1	72	67.7	24.6	132	124.0	45.1	192	180.4	65.7	252	236.8	86.2
13	12.2	04.4	73	68.6	25.0	133	125.0	45.5	193	181.4	66.0	253	237.7	86.5
14	13.2	04.8	74	69.5	25.3	134	125.9	45.8	194	182.3	66.4	254	238.7	86.9
15	14.1	05.1	75	70.5	25.7	135	126.9	46.2	195	183.2	66.7	255	239.6	87.2
16	15.0	05.5	76	71.4	26.0	136	127.8	46.5	196	184.2	67.0	256	240.6	87.6
17	16.0	05.8	77	72.4	26.3	137	128.7	46.9	197	185.1	67.4	257	241.5	87.9
18	16.9	06.2	78	73.3	26.7	138	129.7	47.2	198	186.1	67.7	258	242.4	88.2
19	17.9	06.5	79	74.2	27.0	139	130.6	47.5	199	187.0	68.1	259	243.4	88.6
20	18.8	06.8	80	75.2	27.4	140	131.6	47.9	200	187.9	68.4	260	244.3	88.9
21	19.7	07.2	81	76.1	27.7	141	132.5	48.2	201	188.9	68.7	261	245.3	89.3
22	20.7	07.5	82	77.1	28.0	142	133.4	48.6	202	189.8	69.1	262	246.2	89.6
23	21.6	07.9	83	78.0	28.4	143	134.4	48.9	203	190.8	69.4	263	247.1	90.0
24	22.6	08.2	84	78.9	28.7	144	135.3	49.3	204	191.7	69.8	264	248.1	90.3
25	23.5	08.6	85	79.9	29.1	145	136.3	49.6	205	192.6	70.1	265	249.0	90.6
26	24.4	08.9	86	80.8	29.4	146	137.2	49.9	206	193.6	70.5	266	250.0	91.0
27	25.4	09.2	87	81.8	29.8	147	138.1	50.3	207	194.5	70.8	267	250.9	91.3
28	26.3	09.6	88	82.7	30.1	148	139.1	50.6	208	195.5	71.1	268	251.8	91.7
29	27.3	09.9	89	83.6	30.4	149	140.0	51.0	209	196.4	71.5	269	252.8	92.0
30	28.2	10.3	90	84.6	30.8	150	141.0	51.3	210	197.3	71.8	270	253.7	92.3
31	29.1	10.6	91	85.5	31.1	151	141.9	51.6	211	198.3	72.2	271	254.7	92.7
32	30.1	10.9	92	86.5	31.5	152	142.8	52.0	212	199.2	72.5	272	255.6	93.0
33	31.0	11.3	93	87.4	31.8	153	143.8	52.3	213	200.2	72.9	273	256.5	93.4
34	31.9	11.6	94	88.3	32.1	154	144.7	52.7	214	201.1	73.2	274	257.5	93.7
35	32.9	12.0	95	89.3	32.5	155	145.7	53.0	215	202.0	73.5	275	258.4	94.1
36	33.8	12.3	96	90.2	32.8	156	146.6	53.4	216	203.0	73.9	276	259.4	94.4
37	34.8	12.7	97	91.2	33.2	157	147.5	53.7	217	203.9	74.2	277	260.3	94.7
38	35.7	13.0	98	92.1	33.5	158	148.5	54.0	218	204.9	74.6	278	261.2	95.1
39	36.6	13.3	99	93.0	33.9	159	149.4	54.4	219	205.8	74.9	279	262.2	95.4
40	37.6	13.7	100	94.0	34.2	160	150.4	54.7	220	206.7	75.2	280	263.1	95.8
41	38.5	14.0	101	94.9	34.5	161	151.3	55.1	221	207.7	75.6	281	264.1	96.1
42	39.5	14.4	102	95.8	34.9	162	152.2	55.4	222	208.6	75.9	282	265.0	96.4
43	40.4	14.7	103	96.8	35.2	163	153.2	55.7	223	209.6	76.3	283	265.9	96.8
44	41.3	15.0	104	97.7	35.6	164	154.1	56.1	224	210.5	76.6	284	266.9	97.1
45	42.3	15.4	105	98.7	35.9	165	155.0	56.4	225	211.4	77.0	285	267.8	97.5
46	43.2	15.7	106	99.6	36.3	166	156.0	56.8	226	212.4	77.3	286	268.8	97.8
47	44.2	16.1	107	100.5	36.6	167	156.9	57.1	227	213.3	77.6	287	269.7	98.2
48	45.1	16.4	108	101.5	36.9	168	157.9	57·5	228	214.2	78.0	288	270.6	98.5
49	46.0	16.8	109	102.4	37.3	169	158.8	57.8	229	215.2	78.3	289	271.6	98.8
50	47.0	17.1	110	103.4	37.6	170	159.7	58.1	230	216.1	78.7	290	272.5	99.2
51	47.9	17.4	111	104.3	38.0	171	160.7	58.5	231	217.1	79.0	291	273.5	99.5
52	48.9	17.8	112	105.2	38.3	172	161.6	58.8	232	218.0	79.3	292	274.4	99.9
53	49.8	18.1	113	106.2	38.6	173	162.6	59.2	233	218.9	79.7	293	275.3	100.2
54	50.7	18.5	114	107.1	39.0	174	163.5	59.5	234	219.9	80.0	294	276.3	100.6
55	51.7	18.8	115	108.1	39.3	175	164.4	59.9	235	220.8	80.4	295	277.2	100.9
56	52.6	19.2	116	109.0	39.7	176	165.4	60.2	236	221.8	80.7	296	278.1	101.2
57	53.6	19.5	117	109.9	40.0	177	166.3	60.5	237	222.7	81.1	297	279.1	101.6
58	54.5	19.8	118	110.9	40.4	178	167.3	60.9	238	223.6	81.4	298	280.0	101.9
59	55.4	20.2	119	111.8	40.7	179	168.2	61.2	239	224.6	81.7	299	281.0	102.3
60	56.4	20.5	120	112.8	41.0	180	169.1	61.6	240	225.5	82.1	300	281.9	102.6
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

TABLE II.

Difference of Latitude and Departure for 21°.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.9	00.4	61	56.9	21.9	121	113.0	43.4	181	169.0	64.9	241	225.0	86.4
2	01.9	00.7	62	57.9	22.2	122	113.9	43.7	182	169.9	65.2	242	225.9	86.7
3	02.8	01.1	63	58.8	22.6	123	114.8	44.1	183	170.8	65.6	243	226.9	87.1
4	03.7	01.4	64	59.7	22.9	124	115.8	44.4	184	171.8	65.9	244	227.8	87.4
5	04.7	01.8	65	60.7	23.3	125	116.7	44.8	185	172.7	66.3	245	228.7	87.8
6	05.6	02.2	66	61.6	23.7	126	117.6	45.2	186	173.6	66.7	246	229.7	88.2
7	06.5	02.5	67	62.5	24.0	127	118.6	45.5	187	174.6	67.0	247	230.6	88.5
8	07.5	02.9	68	63.5	24.4	128	119.5	45.9	188	175.5	67.4	248	231.5	88.9
9	08.4	03.2	69	64.4	24.7	129	120.4	46.2	189	176.4	67.7	249	232.5	89.2
10	09.3	03.6	70	65.4	25.1	130	121.4	46.6	190	177.4	68.1	250	233.4	89.6
11	10.3	03.9	71	66.3	25.4	131	122.3	46.9	191	178.3	68.4	251	234.3	90.0
12	11.2	04.3	72	67.2	25.8	132	123.2	47.3	192	179.2	68.8	252	235.3	90.3
13	12.1	04.7	73	68.2	26.2	133	124.2	47.7	193	180.2	69.2	253	236.2	90.7
14	13.1	05.0	74	69.1	26.5	134	125.1	48.0	194	181.1	69.5	254	237.1	91.0
15	14.0	05.4	75	70.0	26.9	135	126.0	48.4	195	182.0	69.9	255	238.1	91.4
16	14.9	05.7	76	71.0	27.2	136	127.0	48.7	196	183.0	70.2	256	239.0	91.7
17	15.9	06.1	77	71.9	27.6	137	127.9	49.1	197	183.9	70.6	257	239.9	92.1
18	16.8	06.5	78	72.8	28.0	138	128.8	49.5	198	184.8	71.0	258	240.9	92.5
19	17.7	06.8	79	73.8	28.3	139	129.8	49.8	199	185.8	71.3	259	241.8	92.8
20	18.7	07.2	80	74.7	28.7	140	130.7	50.2	200	186.7	71.7	260	242.7	93.2
21	19.6	07.5	81	75.6	29.0	141	131.6	50.5	201	187.6	72.0	261	243.7	93.5
22	20.5	07.9	82	76.6	29.4	142	132.6	50.9	202	188.6	72.4	262	244.6	93.9
23	21.5	08.2	83	77.5	29.7	143	133.5	51.2	203	189.5	72.7	263	245.5	94.3
24	22.4	08.6	84	78.4	30.1	144	134.4	51.6	204	190.5	73.1	264	246.5	94.6
25	23.3	09.0	85	79.4	30.5	145	135.4	52.0	205	191.4	73.5	265	247.4	95.0
26	24.3	09.3	86	80.3	30.8	146	136.3	52.3	206	192.3	73.8	266	248.3	95.3
27	25.2	09.7	87	81.2	31.2	147	137.2	52.7	207	193.3	74.2	267	249.3	95.7
28	26.1	10.0	88	82.2	31.5	148	138.2	53.0	208	194.2	74.5	268	250.2	96.0
29	27.1	10.4	89	83.1	31.9	149	139.1	53.4	209	195.1	74.9	269	251.1	96.4
30	28.0	10.8	90	84.0	32.3	150	140.0	53.8	210	196.1	75.3	270	252.1	96.8
31	28.9	11.1	91	85.0	32.6	151	141.0	54.1	211	197.0	75.6	271	253.0	97.1
32	29.9	11.5	92	85.9	33.0	152	141.9	54.5	212	197.9	76.0	272	253.9	97.5
33	30.8	11.8	93	86.8	33.3	153	142.8	54.8	213	198.9	76.3	273	254.9	97.8
34	31.7	12.2	94	87.8	33.7	154	143.8	55.2	214	199.8	76.7	274	255.8	98.2
35	32.7	12.5	95	88.7	34.0	155	144.7	55.5	215	200.7	77.0	275	256.7	98.6
36	33.6	12.9	96	89.6	34.4	156	145.6	55.9	216	201.7	77.4	276	257.7	98.9
37	34.5	13.3	97	90.6	34.8	157	146.6	56.3	217	202.6	77.8	277	258.6	99.3
38	35.5	13.6	98	91.5	35.1	158	147.5	56.6	218	203.5	78.1	278	259.5	99.6
39	36.4	14.0	99	92.4	35.5	159	148.4	57.0	219	204.5	78.5	279	260.5	100.0
40	37.3	14.3	100	93.4	35.8	160	149.4	57.3	220	205.4	78.8	280	261.4	100.3
41	38.3	14.7	101	94.3	36.2	161	150.3	57.7	221	206.3	79.2	281	262.3	100.7
42	39.2	15.1	102	95.2	36.6	162	151.2	58.1	222	207.3	79.6	282	263.3	101.1
43	40.1	15.4	103	96.2	36.9	163	152.2	58.4	223	208.2	79.9	283	264.2	101.4
44	41.1	15.8	104	97.1	37.3	164	153.1	58.8	224	209.1	80.3	284	265.1	101.8
45	42.0	16.1	105	98.0	37.6	165	154.0	59.1	225	210.1	80.6	285	266.1	102.1
46	42.9	16.5	106	99.0	38.0	166	155.0	59.5	226	211.0	81.0	286	267.0	102.5
47	43.9	16.8	107	99.9	38.3	167	155.9	59.8	227	211.9	81.3	287	267.9	102.9
48	44.8	17.2	108	100.8	38.7	168	156.8	60.2	228	212.9	81.7	288	268.9	103.2
49	45.7	17.6	109	101.8	39.1	169	157.8	60.6	229	213.8	82.1	289	269.8	103.6
50	46.7	17.9	110	102.7	39.4	170	158.7	60.9	230	214.7	82.4	290	270.7	103.9
51	47.6	18.3	111	103.6	39.8	171	159.6	61.3	231	215.7	82.8	291	271.7	104.3
52	48.5	18.6	112	104.6	40.1	172	160.6	61.6	232	216.6	83.1	292	272.6	104.6
53	49.5	19.0	113	105.5	40.5	173	161.5	62.0	233	217.5	83.5	293	273.5	105.0
54	50.4	19.4	114	106.4	40.9	174	162.4	62.4	234	218.5	83.9	294	274.5	105.4
55	51.3	19.7	115	107.4	41.2	175	163.4	62.7	235	219.4	84.2	295	275.4	105.7
56	52.3	20.1	116	108.3	41.6	176	164.3	63.1	236	220.3	84.6	296	276.3	106.1
57	53.2	20.4	117	109.2	41.9	177	165.2	63.4	237	221.3	84.9	297	277.3	106.4
58	54.1	20.8	118	110.2	42.3	178	166.2	63.8	238	222.2	85.3	298	278.2	106.8
59	55.1	21.1	119	111.1	42.6	179	167.1	64.1	239	223.1	85.6	299	279.1	107.2
60	56.0	21.5	120	112.0	43.0	180	168.0	64.5	240	224.1	86.0	300	280.1	107.5
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Difference of Latitude and Departure for 22°.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.9	00.4	61	56.6	22.9	121	112.2	45.3	181	167.8	67.8	241	223.5	90.3
2	01.9	00.7	62	57.5	23.2	122	113.1	45.7	182	168.7	68.2	242	224.4	90.7
3	02.8	01.1	63	58.4	23.6	123	114.0	46.1	183	169.7	68.6	243	225.3	91.0
4	03.7	01.5	64	59.3	24.0	124	115.0	46.5	184	170.6	68.9	244	226.2	91.4
5	04.6	01.9	65	60.3	24.3	125	115.9	46.8	185	171.5	69.3	245	227.2	91.8
6	05.6	02.2	66	61.2	24.7	126	116.8	47.2	186	172.5	69.7	246	228.1	92.2
7	06.5	02.6	67	62.1	25.1	127	117.8	47.6	187	173.4	70.1	247	229.0	92.5
8	07.4	03.0	68	63.0	25.5	128	118.7	47.9	188	174.3	70.4	248	229.9	92.9
9	08.3	03.4	69	64.0	25.8	129	119.6	48.3	189	175.2	70.8	249	230.9	93.3
10	09.3	03.7	70	64.9	26.2	130	120.5	48.7	190	176.2	71.2	250	231.8	93.7
11	10.2	04.1	71	65.8	26.6	131	121.5	49.1	191	177.1	71.5	251	232.7	94.0
12	11.1	04.5	72	66.8	27.0	132	122.4	49.4	192	178.0	71.9	252	233.7	94.4
13	12.1	04.9	73	67.7	27.3	133	123.3	49.8	193	178.9	72.3	253	234.6	94.8
14	13.0	05.2	74	68.6	27.7	134	124.2	50.2	194	179.9	72.7	254	235.5	95.2
15	13.9	05.6	75	69.5	28.1	135	125.2	50.6	195	180·8	73.0	255	236.4	95.5
16	14.8	06.0	76	70.5	28.5	136	126.1	50.9	196	181.7	73.4	256	237.4	95.9
17	15.8	06.4	77	71.4	28.8	137	127.0	51.3	197	182.7	73.8	257	238.3	96.3
18	16.7	06.7	78	72.3	29.2	138	128.0	51.7	198	183.6	74.2	258	239.2	96.6
19	17.6	07.1	79	73.2	29.6	139	128.9	52.1	199	184.5	74.5	259	240.1	97.0
20	18.5	07.5	80	74.2	30.0	140	129.8	52.4	200	185.4	74.9	260	241.1	97.4
21	19.5	07.9	81	75.1	30.3	141	130.7	52.8	201	186.4	75.3	261	242.0	97.8
22	20.4	08.2	82	76.0	30.7	142	131.7	53.2	202	187.3	75.7	262	242.9	98.1
23	21.3	08.6	83	77.0	31.1	143	132.6	53.6	203	188.2	76.0	263	243.8	98.5
24	22.3	09.0	84	77.9	31.5	144	133.5	53.9	204	189.1	76.4	264	244.8	98.9
25	23.2	09.4	85	78.8	31.8	145	134.4	54.3	205	190.1	76.8	265	245.7	99.3
26	24.1	09.7	86	79.7	32.2	146	135.4	54.7	206	191.0	77.2	266	246.6	99.6
27	25.0	10.1	87	80.7	32.6	147	136.3	55.1	207	191.9	77.5	267	247.6	100.0
28	26.0	10.5	88	81.6	33.0	148	137.2	55.4	208	192.9	77.9	268	248.5	100.4
29	26.9	10.9	89	82.5	33.3	149	138.2	55.8	209	193.8	78.3	269	249.4	100.8
30	27.8	11.2	90	83.4	33.7	150	139.1	56.2	210	194.7	78.7	270	250.3	101.1
31	28.7	11.6	91	84.4	34.1	151	140.0	56.6	211	195.6	79.0	271	251.3	101.5
32	29.7	12.0	92	85.3	34.5	152	140.9	56.9	212	196.6	79.4	272	252.2	101.9
33	30.6	12.4	93	86.2	34.8	153	141.9	57.3	213	197.5	79.8	273	253.1	102.3
34	31.5	12.7	94	87.2	35.2	154	142.8	57.7	214	198.4	80.2	274	254.0	102.6
35	32.5	13.1	95	88.1	35.6	155	143.7	58.1	215	199.3	80.5	275	255.0	103.0
36	33.4	13.5	96	89.0	36.0	156	144.6	58.4	216	200.3	80.9	276	255.9	103.4
37	34.3	13.9	97	89.9	36.3	157	145.6	58.8	217	201.2	81.3	277	256.8	103.8
38	35.2	14.2	98	90.9	36.7	158	146.5	59.2	218	202.1	81.7	278	257.8	104.1
39	36.2	14.6	99	91.8	37.1	159	147.4	59.6	219	203.1	82.0	279	258.7	104.5
40	37.1	15.0	100	92.7	37.5	160	148.3	59.9	220	204.0	82.4	280	259.6	104.9
41	38.0	15.4	101	93.6	37.8	161	149.3	60.3	221	204.9	82.8	281	260.5	105.3
42	38.9	15.7	102	94.6	38.2	162	150.2	60.7	222	205.8	83.2	282	261.5	105.6
43	39.9	16.1	103	95.5	38.6	163	151.1	61.1	223	206.8	83.5	283	262.4	106.0
44	40.8	16.5	104	96.4	39.0	164	152.1	61.4	224	207.7	83.9	284	263.3	106.4
45	41.7	16.9	105	97.4	39.3	165	153.0	61.8	225	208.6	84.3	285	264.2	106.8
46	42.7	17.2	106	98.3	39.7	166	153.9	62.2	226	209.5	84.7	286	265.2	107.1
47	43.6	17.6	107	99.2	40.1	167	154.8	62.6	227	210.5	85.0	287	266.1	107.5
48	44.5	18.0	108	100.1	40.5	168	155.8	62.9	228	211.4	85.4	288	267.0	107.9
49	45.4	18.4	109	101.1	40.8	169	156.7	63.3	229	212.3	85.8	289	268.0	108.3
50	46.4	18.7	110	102.0	41.2	170	157.6	63.7	230	213.3	86.2	290	268.9	108.6
51	47.3	19.1	111	102.9	41.6	171	158.5	64.1	231	214.2	86.5	291	269.8	109.0
52	48.2	19.5	112	103.8	42.0	172	159.5	64.4	232	215.1	86.9	292	270.7	109.4
53	49.1	19.9	113	104.8	42.3	173	160.4	64.8	233	216.0	87.3	293	271.7	109.8
54	50.1	20.2	114	105.7	42.7	174	161.3	65.2	234	217.0	87.7	294	272.6	110.1
55	51.0	20.6	115	106.6	43.1	175	162.3	65.6	235	217.9	88.0	295	273.5	110.5
56	51.9	21.0	116	107.6	43.5	176	163.2	65.9	236	218.8	88.4	296	274.4	110.9
57	52.8	21.4	117	108.5	43.8	177	164.1	66.3	237	219.7	88.8	297	275.4	111.3
58	53.8	21.7	118	109.4	44.2	178	165.0	66.7	238	220.7	89.2	298	276.3	111.6
59	54.7	22.1	119	110.3	44.6	179	166.0	67.1	239	221.6	89.5	299	277.2	112.0
60	55.6	22.5	120	111.3	45.0	180	166.9	67.4	240	222.5	89.9	300	278.2	112.4
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Difference of Latitude and Departure for 23°.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.9	00.4	61	56.2	23.8	121	111.4	47.3	181	166.6	70.7	241	221.8	94.2
2	01.8	00.8	62	57.1	24.2	122	112.3	47.7	182	167.5	71.1	242	222.8	94.6
3	02.8	01.2	63	58.0	24.6	123	113.2	48.1	183	168.5	71.5	243	223.7	94.9
4	03.7	01.6	64	58.9	25.0	124	114.1	48.5	184	169.4	71.9	244	224.6	95.3
5	04.6	02.0	65	59.8	25.4	125	115.1	48.8	185	170.3	72.3	245	225.5	95.7
6	05.5	02.3	66	60.8	25.8	126	116.0	49.2	186	171.2	72.7	246	226.4	96.1
7	06.4	02.7	67	61.7	26.2	127	116.9	49.6	187	172.1	73.1	247	227.4	96.5
8	07.4	03.1	68	62.6	26.6	128	117.8	50.0	188	173.1	73.5	248	228.3	96.9
9	08.3	03.5	69	63.5	27.0	129	118.7	50.4	189	174.0	73.8	249	229.2	97.3
10	09.2	03.9	70	64.4	27.4	130	119.7	50.8	190	174.9	74.2	250	230.1	97.7
11	10.1	04.3	71	65.4	27.7	131	120.6	51.2	191	175.8	74.6	251	231.0	98.1
12	11.0	04.7	72	66.3	28.1	132	121.5	51.6	192	176.7	75.0	252	232.0	98.5
13	12.0	05.1	73	67.2	28.5	133	122.4	52.0	193	177.7	75.4	253	232.9	98.9
14	12.9	05.5	74	68.1	28.9	134	123.3	52.4	194	178.6	75.8	254	233.8	99.2
15	13.8	05.9	75	69.0	29.3	135	124.3	52.7	195	179.5	76.2	255	234.7	99.6
16	14.7	06.3	76	70.0	29.7	136	125.2	53.1	196	180.4	76.6	256	235.6	100.0
17	15.6	06.6	77	70.9	30.1	137	126.1	53.5	197	181.3	77.0	257	236.6	100.4
18	16.6	07.0	78	71.8	30.5	138	127.0	53.9	198	182.3	77.4	258	237.5	100.8
19	17.5	07.4	79	72.7	30.9	139	128.0	54.3	199	183.2	77.8	259	238.4	101.2
20	18.4	07.8	80	73.6	31.3	140	128.9	54.7	200	184.1	78.1	260	239.3	101.6
21	19.3	08.2	81	74.6	31.6	141	129.8	55.1	201	185.0	78.5	261	240.3	102.0
22	20.3	08.6	82	75.5	32.0	142	130.7	55.5	202	185.9	78.9	262	241.2	102.4
23	21.2	09.0	83	76.4	32.4	143	131.6	55.9	203	186.9	79.3	263	242.1	102.8
24	22.1	09.4	84	77.3	32.8	144	132.6	56.3	204	187.8	79.7	264	243.0	103.2
25	23.0	09.8	85	78.2	33.2	145	133.5	56.7	205	188.7	80.1	265	243.9	103.5
26	23.9	10.2	86	79.2	33.6	146	134.4	57.0	206	189.6	80.5	266	244.9	103.9
27	24.9	10.5	87	80.1	34.0	147	135.3	57.4	207	190.5	80.9	267	245.8	104.3
28	25.8	10.9	88	81.0	34.4	148	136.2	57.8	208	191.5	81.3	268	246.7	104.7
29	26.7	11.3	89	81.9	34.8	149	137.2	58.2	209	192.4	81.7	269	247.6	105.1
30	27.6	11.7	90	82.8	35.2	150	138.1	58.6	210	193.3	82.1	270	248.5	105.5
31	28.5	12.1	91	83.8	35.6	151	139.0	59.0	211	194.2	82.4	271	249.5	105.9
32	29.5	12.5	92	84.7	35.9	152	139.9	59.4	212	195.1	82.8	272	250.4	106.3
33	30.4	12.9	93	85.6	36.3	153	140.8	59.8	213	196.1	83.2	273	251.3	106.7
34	31.3	13.3	94	86.5	36.7	154	141.8	60.2	214	197.0	83.6	274	252.2	107.1
35	32.2	13.7	95	87.4	37.1	155	142.7	60.6	215	197.9	84.0	275	253.1	107.5
36	33.1	14.1	96	88.4	37.5	156	143.6	61.0	216	198.8	84.4	276	254.1	107.8
37	34.1	14.5	97	89.3	37.9	157	144.5	61.3	217	199.7	84.8	277	255.0	108.2
38	35.0	14.8	98	90.2	38.3	158	145.4	61.7	218	200.7	85.2	278	255.9	108.6
39	35.9	15.2	99	91.1	38.7	159	146.4	62.1	219	201.6	85.6	279	256.8	109.0
40	36.8	15.6	100	92.1	39.1	160	147.3	62.5	220	202.5	86.0	280	257.7	109.4
41	37.7	16.0	101	93.0	39.5	161	148.2	62.9	221	203.4	86.4	281	258.7	109.8
42	38.7	16.4	102	93.9	39.9	162	149.1	63.3	222	204.4	86.7	282	259.6	110.2
43	39.6	16.8	103	94.8	40.2	163	150.0	63.7	223	205.3	87.1	283	260.5	110.6
44	40.5	17.2	104	95.7	40.6	164	151.0	64.1	224	206.2	87.5	284	261.4	111.0
45	41.4	17.6	105	96.7	41.0	165	151.9	64.5	225	207.1	87.9	285	262.3	111.4
46	42.3	18.0	106	97.6	41.4	166	152.8	64.9	226	208.0	88.3	286	263.3	111.7
47	43.3	18.4	107	98.5	41.8	167	153.7	65.3	227	209.0	88.7	287	264.2	112.1
48	44.2	18.8	108	99.4	42.2	168	154.6	65.6	228	209.9	89.1	288	265.1	112.5
49	45.1	19.1	109	100.3	42.6	169	155.6	66.0	229	210.8	89.5	289	266.0	112.9
50	46.0	19.5	110	101.3	43.0	170	156.5	66.4	230	211.7	89.9	290	266.9	113.3
51	46.9	19.9	111	102.2	43.4	171	157.4	66.8	231	212.6	90.3	291	267.9	113.7
52	47.9	20.3	112	103.1	43.8	172	158.3	67.2	232	213.6	90.6	292	268.8	114.1
53	48.8	20.7	113	104.0	44.2	173	159.2	67.6	233	214.5	91.0	293	269.7	114.5
54	49.7	21.1	114	104.9	44.5	174	160.2	68.0	234	215.4	91.4	294	270.6	114.9
55	50.6	21.5	115	105.9	44.9	175	161.1	68.4	235	216.3	91.8	295	271.5	115.3
56	51.5	21.9	116	106.8	45.3	176	162.0	68.8	236	217.2	92.2	296	272.5	115.7
57	52.5	22.3	117	107.7	45.7	177	162.9	69.2	237	218.2	92.6	297	273.4	116.0
58	53.4	22.7	118	108.6	46.1	178	163.8	69.6	238	219.1	93.0	298	274.3	116.4
59	54.3	23.1	119	109.5	46.5	179	164.8	69.9	239	220.0	93.4	299	275.2	116.8
60	55.2	23.4	120	110.5	46.9	180	165.7	70.3	240	220.9	93.8	300	276.2	117.2
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Difference of Latitude and Departure for 24°.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.9	00.4	61	55.7	24.8	121	110.5	49.2	181	165.4	73.6	241	220.2	98.0
2	01.8	00.8	62	56.6	25.2	122	111.5	49.6	182	166.3	74.0	242	221.1	98.4
3	02.7	01.2	63	57.6	25.6	123	112.4	50.0	183	167.2	74.4	243	222.0	98.8
4	03.7	01.6	64	58.5	26.0	124	113.3	50.4	184	168.1	74.8	244	222.9	99.2
5	04.6	02.0	65	59.4	26.4	125	114.2	50.8	185	169.0	75.2	245	223.8	99.7
6	05.5	02.4	66	60.3	26.8	126	115.1	51.2	186	169.9	75.7	246	224.7	100.1
7	06.4	02.8	67	61.2	27.3	127	116.0	51.7	187	170.8	76.1	247	225.6	100.5
8	07.3	03.3	68	62.1	27.7	128	116.9	52.1	188	171.7	76.5	248	226.6	100.9
9	08.2	03.7	69	63.0	28.1	129	117.8	52.5	189	172.7	76.9	249	227.5	101.3
10	09.1	04.1	70	63.9	28.5	130	118.8	52.9	190	173.6	77.3	250	228.4	101.7
11	10.0	04.5	71	64.9	28.9	131	119.7	53.3	191	174.5	77.7	251	229.3	102.1
12	11.0	04.9	72	65.8	29.3	132	120.6	53.7	192	175.4	78.1	252	230.2	102.5
13	11.9	05.3	73	66.7	29.7	133	121.5	54.1	193	176.3	78.5	253	231.1	102.9
14	12.8	05.7	74	67.6	30.1	134	122.4	54.5	194	177.2	78.9	254	232.0	103.3
15	13.7	06.1	75	68.5	30.5	135	123.3	54.9	195	178.1	79.3	255	233.0	103.7
16	14.6	06.5	76	69.4	30.9	136	124.2	55.3	196	179.1	79.7	256	233.9	104.1
17	15.5	06.9	77	70.3	31.3	137	125.2	55.7	197	180.0	80.1	257	234.8	104.5
18	16.4	07.3	78	71.3	31.7	138	126.1	56.1	198	180.9	80.5	258	235.7	104.9
19	17.4	07.7	79	72.2	32.1	139	127.0	56.5	199	181.8	80.9	259	236.6	105.3
20	18.3	08.1	80	73.1	32.5	140	127.9	56.9	200	182.7	81.3	260	237.5	105.8
21	19.2	08.5	81	74.0	32.9	141	128.8	57.3	201	183.6	81.8	261	238.4	106.2
22	20.1	08.9	82	74.9	33.4	142	129.7	57.8	202	184.5	82.2	262	239.3	106.6
23	21.0	09.4	83	75.8	33.8	143	130.6	58.2	203	185.4	82.6	263	240.3	107.0
24	21.9	09.8	84	76.7	34.2	144	131.6	58.6	204	186.4	83.0	264	241.2	107.4
25	22.8	10.2	85	77.7	34.6	145	132.5	59.0	205	187.3	83.4	265	242.1	107.8
26	23.8	10.6	86	78.6	35.0	146	133.4	59.4	206	188.2	83.8	266	243.0	108.2
27	24.7	11.0	87	79.5	35.4	147	134.3	59.8	207	189.1	84.2	267	243.9	108.6
28	25.6	11.4	88	80.4	35.8	148	135.2	60.2	208	190.0	84.6	268	244.8	109.0
29	26.5	11.8	89	81.3	36.2	149	136.1	60.6	209	190.9	85.0	269	245.7	109.4
30	27.4	12.2	90	82.2	36.6	150	137.0	61.0	210	191.8	85.4	270	246.7	109.8
31	28.3	12.6	91	83.1	37.0	151	137.9	61.4	211	192.8	85.8	271	247.6	110.2
32	29.2	13.0	92	84.0	37.4	152	138.9	61.8	212	193.7	86.2	272	248.5	110.6
33	30.1	13.4	93	85.0	37.8	153	139.8	62.2	213	194.6	86.6	273	249.4	111.0
34	31.1	13.8	94	85.9	38.2	154	140.7	62.6	214	195.5	87.0	274	250.3	111.4
35	32.0	14.2	95	86.8	38.6	155	141.6	63.0	215	196.4	87.4	275	251.2	111.9
36	32.9	14.6	96	87.7	39.0	156	142.5	63.5	216	197.3	87.9	276	252.1	112.3
37	33.8	15.0	97	88.6	39.5	157	143.4	63.9	217	198.2	88.3	277	253.1	112.7
38	34.7	15.5	98	89.5	39.9	158	144.3	64.3	218	199.2	88.7	278	254.0	113.1
39	35.6	15.9	99	90.4	40.3	159	145.3	64.7	219	200.1	89.1	279	254.9	113.5
40	36.5	16.3	100	91.4	40.7	160	146.2	65.1	220	201.0	89.5	280	255.8	113.9
41	37.5	16.7	101	92.3	41.1	161	147.1	65.5	221	201.9	89.9	281	256.7	114.3
42	38.4	17.1	102	93.2	41.5	162	148.0	65.9	222	202.8	90.3	282	257.6	114.7
43	39.3	17.5	103	94.1	41.9	163	148.9	66.3	223	203.7	90.7	283	258.5	115.1
44	40.2	17.9	104	95.0	42.3	164	149.8	66.7	224	204.6	91.1	284	259.4	115.5
45	41.1	18.3	105	95.9	42.7	165	150.7	67.1	225	205.5	91.5	285	260.4	115.9
46	42.0	18.7	106	96.8	43.1	166	151.6	67.5	226	206.5	91.9	286	261.3	116.3
47	42 9	19.1	107	97.7	43.5	167	152.6	67.9	227	207.4	92.3	287	262.2	116.7
48	43.9	19.5	108	98.7	43.9	168	153.5	68.3	228	208.3	92.7	288	263.1	117.1
49	44.8	19.9	109	99.6	44.3	169	154.4	68.7	229	209.2	93.1	289	264.0	117.5
50	45.7	20.3	110	100.5	44.7	170	155.3	69.1	230	210.1	93.5	290	264.9	118.0
51	46.6	20.7	111	101.4	45.1	171	156.2	69.6	231	211.0	94.0	291	265.8	118.4
52	47.5	21.2	112	102.3	45.6	172	157.1	70.0	232	211.9	94.4	292	266.8	118.8
53	48.4	21.6	113	103.2	46.0	173	158.0	70.4	233	212.9	94.8	293	267.7	119.2
54	49.3	22.0	114	104.1	46.4	174	159.0	70.8	234	213.8	95.2	294	268.6	119.6
55	50.2	22.4	115	105.1	46.8	175	159.9	71.2	235	214.7	95.6	295	269.5	120.0
56	51.2	22.8	116	106.0	47.2	176	160.8	71.6	236	215.6	96.0	296	270.4	120.4
57	52.1	23.2	117	106.9	47.6	177	161.7	72.0	237	216.5	96.4	297	271.3	120.8
58	53.0	23.6	118	107.8	48.0	178	162.6	72.4	238	217.4	96.8	298	272.2	121.2
59	53.9	24.0	119	108.7	48.4	179	163.5	72.8	239	218.3	97.2	299	273.2	121.6
60	54.8	24.4	120	109.6	48.8	180	164.4	73.2	240	219.3	97.6	300	274.1	122.0
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Difference of Latitude and Departure for 25°.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.9	00.4	61	55.3	25.8	121	109.7	51.1	181	164.0	76.5	241	218.4	101.9
2	01.8	00.8	62	56.2	26.2	122	110.6	51.6	182	164.9	76.9	242	219.3	102.3
3	02.7	01.3	63	57.1	26.6	123	111.5	52.0	183	165.9	77.3	243	220.2	102.7
4	03.6	01.7	64	58.0	27.0	124	112.4	52.4	184	166.8	77.8	244	221.1	103.1
5	04.5	02.1	65	58.9	27.5	125	113.3	52.8	185	167.7	78.2	245	222.0	103.5
6	05.4	02.5	66	59.8	27.9	126	114.2	53.2	186	168.6	78.6	246	223.0	104.0
7	06.3	03.0	67	60.7	28.3	127	115.1	53.7	187	169.5	79.0	247	223.9	104.4
8	07.3	03.4	68	61.6	28.7	128	116.0	54.1	188	170.4	79.5	248	224.8	104.8
9	08.2	03.8	69	62.5	29.2	129	116.9	54.5	189	171.3	79.9	249	225.7	105.2
10	09.1	04.2	70	63.4	29.6	130	117.8	54.9	190	172.2	80.3	250	226.6	105.7
11	10.0	04.6	71	64.3	30.0	131	118.7	55.4	191	173.1	80.7	251	227.5	106.1
12	10.9	05.1	72	65.3	30.4	132	119.6	55.8	192	174.0	81.1	252	228.4	106.5
13	11.8	05.5	73	66.2	30.9	133	120.5	56.2	193	174.9	81.6	253	229.3	106.9
14	12.7	05.9	74	67.1	31.3	134	121.4	56.6	194	175.8	82.0	254	230.2	107.3
15	13.6	06.3	75	68.0	31.7	135	122.4	57.1	195	176.7	82.4	255	231.1	107.8
16	14.5	06.8	76	68.9	32.1	136	123.3	57.5	196	177.6	82.8	256	232.0	108.2
17	15.4	07.2	77	69.8	32.5	137	124.2	57.9	197	178.5	83.3	257	232.9	108.6
18	16.3	07.6	78	70.7	33.0	138	125.1	58.3	198	179.4	83.7	258	233.8	109.0
19	17.2	08.0	79	71.6	33.4	139	126.0	58.7	199	180.4	84.1	259	234.7	109.5
20	18.1	08.5	80	72.5	33.8	140	126.9	59.2	200	181.3	84.5	260	235.6	109.9
21	19.0	08.9	81	73.4	34.2	141	127.8	59.6	201	182.2	84.9	261	236.5	110.3
22	19.9	09.3	82	74.3	34.7	142	128.7	60.0	202	183.1	85.4	262	237.5	110.7
23	20.8	09.7	83	75.2	35.1	143	129.6	60.4	203	184.0	85.8	263	238.4	111.1
24	21.8	10.1	84	76.1	35.5	144	130.5	60.9	204	184.9	86.2	264	239.3	111.6
25	22.7	10.6	85	77.0	35.9	145	131.4	61.3	205	185.8	86.6	265	240.2	112.0
26	23.6	11.0	86	77.9	36.3	146	132.3	61.7	206	186.7	87.1	266	241.1	112.4
27	24.5	11.4	87	78.8	36.8	147	133.2	62.1	207	187.6	87.5	267	242.0	112.8
28	25.4	11.8	88	79.8	37.2	148	134.1	62.5	208	188.5	87.9	268	242.9	113.3
29	26.3	12.3	89	80.7	37.6	149	135.0	63.0	209	189.4	88.3	269	243.8	113.7
30	27.2	12.7	90	81.6	38.0	150	135.9	63.4	210	190.3	88.7	270	244.7	114.1
31	28.1	13.1	91	82.5	38.5	151	136.9	63.8	211	191.2	89.2	271	245.6	114.5
32	29.0	13.5	92	83.4	38.9	152	137.8	64.2	212	192.1	89.6	272	246.5	115.0
33	29.9	13.9	93	84.3	39.3	153	138.7	64.7	213	193.0	90.0	273	247.4	115.4
34	30.8	14.4	94	85.2	39.7	154	139.6	65.1	214	193.9	90.4	274	248.3	115.8
35	31.7	14.8	95	86.1	40.1	155	140.5	65.5	215	194.9	90.9	275	249.2	116.2
36	32.6	15.2	96	87.0	40.6	156	141.4	65.9	216	195.8	91.3	276	250.1	116.6
37	33.5	15.6	97	87.9	41.0	157	142.3	66.4	217	196.7	91.7	277	251.0	117.1
38	34.4	16.1	98	88.8	41.4	158	143.2	66.8	218	197.6	92.1	278	252.0	117.5
39	35.3	16.5	99	89.7	41.8	159	144.1	67.2	219	198.5	92.6	279	252.9	117.9
40	36.3	16.9	100	90.6	42.3	160	145.0	67.6	220	199.4	93.0	280	253.8	118.3
41	37.2	17.3	101	91.5	42.7	161	145.9	68.0	221	200.3	93.4	281	254.7	118.8
42	38.1	17.7	102	92.4	43.1	162	146.8	68.5	222	201.2	93.8	282	255.6	119.2
43	39.0	18.2	103	93.3	43.5	163	147.7	68.9	223	202.1	94.2	283	256.5	119.6
44	39.9	18.6	104	94.3	44.0	164	148.6	69.3	224	203.0	94.7	284	257.4	120.0
45	40.8	19.0	105	95.2	44.4	165	149.5	69.7	225	203.9	95.1	285	258.3	120.4
46	41.7	19.4	106	96.1	44.8	166	150.4	70.2	226	204.8	95.5	286	259.2	120.9
47	42.6	19.9	107	97.0	45.2	167	151.4	70.6	227	205.7	95.9	287	260.1	121.3
48	43.5	20.3	108	97.9	45.6	168	152.3	71.0	228	206.6	96.4	288	261.0	121.7
49	44.4	20.7	109	98.8	46.1	169	153.2	71.4	229	207.5	96.8	289	261.9	122.1
50	45.3	21.1	110	99.7	46.5	170	154.1	71.8	230	208.5	97.2	290	262.8	122.6
51	46.2	21.6	111	100.6	46.9	171	155.0	72.3	231	209.4	97.6	291	263.7	123.0
52	47.1	22.0	112	101.5	47.3	172	155.9	72.7	232	210.3	98.0	292	264.6	123.4
53	48.0	22.4	113	102.4	47.8	173	156.8	73.1	233	211.2	98.5	293	265.5	123.8
54	48.9	22.8	114	103.3	48.2	174	157.7	73.5	234	212.1	98.9	294	266.5	124.2
55	49.8	23.2	115	104.2	48.6	175	158.6	74.0	235	213.0	99.3	295	267.4	124.7
56	50.8	23.7	116	105.1	49.0	176	159.5	74.4	236	213.9	99.7	296	268.3	125.1
57	51.7	24.1	117	106.0	49.4	177	160.4	74.8	237	214.8	100.2	297	269.2	125.5
58	52.6	24.5	118	106.9	49.9	178	161.3	75.2	238	215.7	100.6	298	270.1	125.9
59	53.5	24.9	119	107.9	50.3	179	162.2	75.6	239	216.6	101.0	299	271.0	126.4
60	54.4	25.4	120	108.8	50.7	180	163.1	76.1	240	217.5	101.4	300	271.9	126.8
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Difference of Latitude and Departure for 26°.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.9	00.4	61	54.8	26.7	121	108.8	53.0	181	162.7	79.3	241	216.6	105.6
2	01.8	00.9	62	55.7	27.2	122	109.7	53.5	182	163.6	79.8	242	217.5	106.1
3	02.7	01.3	63	56.6	27.6	123	110.6	53.9	183	164.5	80.2	243	218.4	106.5
4	03.6	01.8	64	57.5	28.1	124	111.5	54.4	184	165.4	80.7	244	219.3	107.0
5	04.5	02.2	65	58.4	28.5	125	112.3	54.8	185	166.3	81.1	245	220.2	107.4
6	05.4	02.6	66	59.3	28.9	126	113.2	55.2	186	167.2	81.5	246	221.1	107.8
7	06.3	03.1	67	60.2	29.4	127	114.1	55.7	187	168.1	82.0	247	222.0	108.3
8	07.2	03.5	68	61.1	29.8	128	115.0	56.1	188	169.0	82.4	248	222.9	108.7
9	08.1	03.9	69	62.0	30.2	129	115.9	56.5	189	169.9	82.9	249	223.8	109.2
10	09.0	04.4	70	62.9	30.7	130	116.8	57.0	190	170.8	83.3	250	224.7	109.6
11	09.9	04.8	71	63.8	31.1	131	117.7	57.4	191	171.7	83.7	251	225.6	110.0
12	10.8	05.3	72	64.7	31.6	132	118.6	57.9	192	172.6	84.2	252	226.5	110.5
13	11.7	05.7	73	65.6	32.0	133	119.5	58.3	193	173.5	84.6	253	227.4	110.9
14	12.6	06.1	74	66.5	32.4	134	120.4	58.7	194	174.4	85.0	254	228.3	111.3
15	13.5	06.6	75	67.4	32.9	135	121.3	59.2	195	175.3	85.5	255	229.2	111.8
16	14.4	07.0	76	68.3	33.3	136	122.2	59.6	196	176.2	85.9	256	230.1	112.2
17	15.3	07.5	77	69.2	33.8	137	123.1	60.1	197	177.1	86.4	257	231.0	112.7
18	16.2	07.9	78	70.1	34.2	138	124.0	60.5	198	178.0	86.8	258	231.9	113.1
19	17.1	08.3	79	71.0	34.6	139	124.9	60.9	199	178.9	87.2	259	232.8	113.5
20	18.0	08.8	80	71.9	35.1	140	125.8	61.4	200	179.8	87.7	260	233.7	114.0
21	18.9	09.2	81	72.8	35.5	141	126.7	61.8	201	180.7	88.1	261	234.6	114.4
22	19.8	09.6	82	73.7	35.9	142	127.6	62.2	202	181.6	88.6	262	235.5	114.9
23	20.7	10.1	83	74.6	36.4	143	128.5	62.7	203	182.5	89.0	263	236.4	115.3
24	21.6	10.5	84	75.5	36.8	144	129.4	63.1	204	183.4	89.4	264	237.3	115.7
25	22.5	11.0	85	76.4	37.3	145	130.3	63.6	205	184.3	89.9	265	238.2	116.2
26	23.4	11.4	86	77.3	37.7	146	131.2	64.0	206	185.2	90.3	266	239.1	116.6
27	24.3	11.8	87	78.2	38.1	147	132.1	64.4	207	186.1	90.7	267	240.0	117.0
28	25.2	12.3	88	79.1	38.6	148	133.0	64.9	208	186.9	91.2	268	240.9	117.5
29	26.1	12.7	89	80.0	39.0	149	133.9	65.3	209	187.8	91.6	269	241.8	117.9
30	27.0	13.2	90	80.9	39.5	150	134.8	65.8	210	188.7	92.1	270	242.7	118.4
31	27.9	13.6	91	81.8	39.9	151	135.7	66.2	211	189.6	92.5	271	243.6	118.8
32	28.8	14.0	92	82.7	40.3	152	136.6	66.6	212	190.5	92.9	272	244.5	119.2
33	29.7	14.5	93	83.6	40.8	153	137.5	67.1	213	191.4	93.4	273	245.4	119.7
34	30.6	14.9	94	84.5	41.2	154	138.4	67.5	214	192.3	93.8	274	246.3	120.1
35	31.5	15.3	95	85.4	41.6	155	139.3	67.9	215	193.2	94.2	275	247.2	120.6
36	32.4	15.8	96	86.3	42.1	156	140.2	68.4	216	194.1	94.7	276	248.1	121.0
37	33.3	16.2	97	87.2	42.5	157	141.1	68.8	217	195.0	95.1	277	249.0	121.4
38	34.2	16.7	98	88.1	43.0	158	142.0	69.3	218	195.9	95.6	278	249.9	121.9
39	35.1	17.1	99	89.0	43.4	159	142.9	69.7	219	196.8	96.0	279	250.8	122.3
40	36.0	17.5	100	89.9	43.8	160	143.8	70.1	220	197.7	96.4	280	251.7	122.7
41	36.9	18.0	101	90.8	44.3	161	144.7	70.6	221	198.6	96.9	281	252.6	123.2
42	37.7	18.4	102	91.7	44.7	162	145.6	71.0	222	199.5	97.3	282	253.5	123.6
43	38.6	18.8	103	92.6	45.2	163	146.5	71.5	223	200.4	97.8	283	254.4	124.1
44	39.5	19.3	104	93.5	45.6	164	147.4	71.9	224	201.3	98.2	284	255.3	124.5
45	40.4	19.7	105	94.4	46.0	165	148.3	72.3	225	202.2	98.6	285	256.2	124.9
46	41.3	20.2	106	95.3	46.5	166	149.2	72.8	226	203.1	99.1	286	257.1	125.4
47	42.2	20.6	107	96.2	46.9	167	150.1	73.2	227	204.0	99.5	287	258.0	125.8
48	43.1	21.0	108	97.1	47.3	168	151.0	73.6	228	204.9	99.9	288	258.9	126.3
49	44.0	21.5	109	98.0	47.8	169	151.9	74.1	229	205.8	100.4	289	259.8	126.7
50	44.9	21.9	110	98.9	48.2	170	152.8	74.5	230	206.7	100.8	290	260.7	127.1
51	45.8	22.4	111	99.8	48.7	171	153.7	75.0	231	207.6	101.3	291	261.5	127.6
52	46.7	22.8	112	100.7	49.1	172	154.6	75.4	232	208.5	101.7	292	262.4	128.0
53	47.6	23.2	113	101.6	49.5	173	155.5	75.8	233	209.4	102.1	293	263.3	128.4
54	48.5	23.7	114	102.5	50.0	174	156.4	76.3	234	210.3	102.6	294	264.2	128.9
55	49.4	24.1	115	103.4	50.4	175	157.3	76.7	235	211.2	103.0	295	265.1	129.3
56	50.3	24.5	116	104.3	50.9	176	158.2	77.2	236	212.1	103.5	296	266.0	129.8
57	51.2	25.0	117	105.2	51.3	177	159.1	77.6	237	213.0	103.9	297	266.9	130.2
58	52.1	25.4	118	106.1	51.7	178	160.0	78.0	238	213.9	104.3	298	267.8	130.6
59	53.0	25.9	119	107.0	52.2	179	160.9	78.5	239	214.8	104.8	299	268.7	131.1
60	53.9	26.3	120	107.9	52.6	180	161.8	78.9	240	215.7	105.2	300	269.6	131.5
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Difference of Latitude and Departure for 27°.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.9	00.5	61	54.4	27.7	121	107.8	54.9	181	161.3	82.2	241	214.7	109.4
2	01.8	00.9	62	55.2	28.1	122	108.7	55.4	182	162.2	82.6	242	215.6	109.9
3	02.7	01.4	63	56.1	28.6	123	109.6	55.8	183	163.1	83.1	243	216.5	110.3
4	03.6	01.8	64	57.0	29.1	124	110.5	56.3	184	163.9	83.5	244	217.4	110.8
5	04.5	02.3	65	57.9	29.5	125	111.4	56.7	185	164.8	84.0	245	218 3	111.2
6	05.3	02.7	66	58.8	30.0	126	112.3	57.2	186	165.7	84.4	246	219.2	111.7
7	06.2	03.2	67	59.7	30.4	127	113.2	57.7	187	166.6	84.9	247	220.1	112.1
8	07.1	03.6	68	60.6	30.9	128	114.0	58.1	188	167.5	85.4	248	221.0	112.6
9	08.0	04.1	69	61.5	31.3	129	114.9	58.6	189	168.4	85.8	249	221.9	113.0
10	08.9	04.5	70	62.4	31.8	130	115.8	59.0	190	169.3	86.3	250	222.8	113.5
11	09.8	05.0	71	63.3	32.2	131	116.7	59.5	191	170.2	86.7	251	223.6	114.0
12	10.7	05.4	72	64.2	32.7	132	117.6	59.9	192	171.1	87.2	252	224.5	114.4
13	11.6	05.9	73	65.0	33.1	133	118.5	60.4	193	172.0	87.6	253	225.4	114.9
14	12.5	06.4	74	65.9	33.6	134	119.4	60.8	194	172.9	88.1	254	226.3	115.3
15	13.4	06.8	75	66.8	34.0	135	120.3	61.3	195	173.7	88.5	255	227.2	115.8
16	14.3	07.3	76	67.7	34.5	136	121.2	61.7	196	174.6	89.0	256	228.1	116.2
17	15.1	07.7	77	68.6	35.0	137	122.1	62.2	197	175.5	89.4	257	229.0	116.7
18	16.0	08.2	78	69.5	35.4	138	123.0	62.7	198	176.4	89.9	258	229.9	117.1
19	16.9	08.6	79	70.4	35.9	139	123.8	63.1	199	177.3	90.3	259	230.8	117.6
20	17.8	09.1	80	71.3	36.3	140	124.7	63.6	200	178.2	90.8	260	231.7	118.0
21	18.7	09.5	81	72.2	36.8	141	125.6	64.0	201	179.1	91.3	261	232.6	118.5
22	19.6	10.0	82	73.1	37.2	142	126.5	64.5	202	180.0	91.7	262	233.4	118.9
23	20.5	10.4	83	74.0	37.7	143	127.4	64.9	203	180.9	92.2	263	234.3	119.4
24	21.4	10.9	84	74.8	38.1	144	128.3	65.4	204	181.8	92.6	264	235.2	119.9
25	22.3	11.3	85	75.7	38.6	145	129.2	65.8	205	182.7	93.1	265	236.1	120.3
26	23.2	11.8	86	76.6	39.0	146	130.1	66.3	206	183.5	93.5	266	237.0	120.8
27	24.1	12.3	87	77.5	39.5	147	131.0	66.7	207	184.4	94.0	267	237.9	121.2
28	24.9	12.7	88	78.4	40.0	148	131.9	67.2	208	185.3	94.4	268	238.8	121.7
29	25.8	13.2	89	79.3	40.4	149	132.8	67.6	209	186.2	94.9	269	239.7	122.1
30	26.7	13.6	90	80.2	40.9	150	133.7	68.1	210	187.1	95.3	270	240.6	122.6
31	27.6	14.1	91	81.1	41.3	151	134.5	68.6	211	188.0	95.8	271	241.5	123.0
32	28.5	14.5	92	82.0	41.8	152	135.4	69.0	212	188.9	96.2	272	242.4	123.5
33	29.4	15.0	93	82.9	42.2	153	136.3	69.5	213	189.8	96.7	273	243.2	123.9
34	30.3	15.4	94	83.8	42.7	154	137.2	69.9	214	190.7	97.2	274	244.1	124.4
35	31.2	15.9	95	84.6	43.1	155	138.1	70.4	215	191.6	97.6	275	245.0	124.8
36	32.1	16.3	96	85.5	43.6	156	139.0	70.8	216	192.5	98.1	276	245.9	125.3
37	33.0	16.8	97	86.4	44.0	157	139.9	71.3	217	193.3	98.5	277	246.8	125.8
38	33.9	17.3	98	87.3	44.5	158	140.8	71.7	218	194.2	99.0	278	247.7	126.2
39	34.7	17.7	99	88.2	44.9	159	141.7	72.2	219	195.1	99.4	279	248.6	126.7
40	35.6	18.2	100	89.1	45.4	160	142.6	72.6	220	196.0	99.9	280	249.5	127.1
41	36.5	18.6	101	90.0	45.9	161	143.5	73.1	221	196.9	100.3	281	250.4	127.6
42	37.4	19.1	102	90.9	46.3	162	144.3	73.5	222	197.8	100.8	282	251.3	128.0
43	38.3	19.5	103	91.8	46.8	163	145.2	74.0	223	198.7	101.2	283	252.2	128.5
44	39.2	20.0	104	92.7	47.2	164	146.1	74.5	224	199.6	101.7	284	253.0	128.9
45	40.1	20.4	105	93.6	47.7	165	147.0	74.9	225	200.5	102.1	285	253.9	129.4
46	41.0	20.9	106	94.4	48.1	166	147.9	75.4	226	201.4	102.6	286	254.8	129.8
47	41.9	21.3	107	95.3	48.6	167	148.8	75.8	227	202.3	103.1	287	255.7	130.3
48	42.8	21.8	108	96.2	49.0	168	149.7	76.3	228	203.1	103.5	288	256.6	130.7
49	43.7	22.2	109	97.1	49.5	169	150.6	76.7	229	204.0	104.0	289	257.5	131.2
50	44.6	22.7	110	98.0	49.9	170	151.5	77.2	230	204.9	104.4	290	258.4	131.7
51	45.4	23.2	111	98.9	50.4	171	152.4	77.6	231	205.8	104.9	291	259.3	132.1
52	46.3	23.6	112	99.8	50.8	172	153.3	78.1	232	206.7	105.3	292	260.2	132.6
53	47.2	24.1	113	100.7	51.3	173	154.1	78.5	233	207.6	105.8	293	261.1	133.0
54	48.1	24.5	114	101.6	51.8	174	155.0	79.0	234	208.5	106.2	294	262.0	133.5
55	49.0	25.0	115	102.5	52.2	175	155.9	79.4	235	209.4	106.7	295	262.8	133.9
56	49.9	25.4	116	103.4	52.7	176	156.8	79.9	236	210.3	107.1	296	263.7	134.4
57	50.8	25.9	117	104.2	53.1	177	157.7	80.4	237	211.2	107.6	297	264.6	134.8
58	51.7	26.3	118	105.1	53.6	178	158.6	80.8	238	212.1	108.0	298	265.5	135.3
59	52.6	26.8	119	106.0	54.0	179	159.5	81.3	239	213.0	108.5	299	266.4	135.7
60	53.5	27.2	120	106.9	54.5	180	160.4	81.7	240	213.8	109.0	300	267.3	136.2
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

TABLE II.

Difference of Latitude and Departure for 28°.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.9	00.5	61	53.9	28.6	121	106.8	56.8	181	159.8	85.0	241	212.8	113.1
2	01.8	00.9	62	54.7	29.1	122	107.7	57.3	182	160.7	85.4	242	213.7	113.6
3	02.6	01.4	63	55.6	29.6	123	108.6	57.7	183	161.6	85.9	243	214.6	114.1
4	03.5	01.9	64	56.5	30.0	124	109.5	58.2	184	162.5	86.4	244	215.4	114.6
5	04.4	02.3	65	57.4	30.5	125	110.4	58.7	185	163.3	86.9	245	216.3	115.0
6	05.3	02.8	66	58.3	31.0	126	111.3	59.2	186	164.2	87.3	246	217.2	115.5
7	06.2	03.3	67	59.2	31.5	127	112.1	59.6	187	165.1	87.8	247	218.1	116.0
8	07.1	03.8	68	60.0	31.9	128	113.0	60.1	188	166.0	88.3	248	219.0	116.4
9	07.9	04.2	69	60.9	32.4	129	113.9	60.6	189	166.9	88.7	249	219.9	116.9
10	08.8	04.7	70	61.8	32.9	130	114.8	61.0	190	167.8	89.2	250	220.7	117.4
11	09.7	05.2	71	62.7	33.3	131	115.7	61.5	191	168.6	89.7	251	221.6	117.8
12	10.6	05.6	72	63.6	33.8	132	116.5	62.0	192	169.5	90.1	252	222.5	118.3
13	11.5	06.1	73	64.5	34.3	133	117.4	62.4	193	170.4	90.6	253	223.4	118.8
14	12.4	06.6	74	65.3	34.7	134	118.3	62.9	194	171.3	91.1	254	224.3	119.2
15	13.2	07.0	75	66.2	35.2	135	119.2	63.4	195	172.2	91.5	255	225.2	119.7
16	14.1	07.5	76	67.1	35.7	136	120.1	63.8	196	173.1	92.0	256	226.0	120.2
17	15.0	08.0	77	68.0	36.1	137	121.0	64.3	197	173.9	92.5	257	226.9	120.7
18	15.9	08.5	78	68.9	36.6	138	121.8	64.8	198	174.8	93.0	258	227.8	121.1
19	16.8	08.9	79	69.8	37.1	139	122.7	65.3	199	175.7	93.4	259	228.7	121.6
20	17.7	09.4	80	70.6	37.6	140	123.6	65.7	200	176.6	93.9	260	229.6	122.1
21	18.5	09.9	81	71.5	38.0	141	124.5	66.2	201	177.5	94.4	261	230.4	122.5
22	19.4	10.3	82	72.4	38.5	142	125.4	66.7	202	178.4	94.8	262	231.3	123.0
23	20.3	10.8	83	73.3	39.0	143	126.3	67.1	203	179.2	95.3	263	232.2	123.5
24	21.2	11.3	84	74.2	39.4	144	127.1	67.6	204	180.1	95.8	264	233.1	123.9
25	22.1	11.7	85	75.1	39.9	145	128.0	68.1	205	181.0	96.2	265	234.0	124.4
26	23.0	12.2	86	75.9	40.4	146	128.9	68.5	206	181.9	96.7	266	234.9	124.9
27	23.8	12.7	87	76.8	40.8	147	129.8	69.0	207	182.8	97.2	267	235.7	125.3
28	24.7	13.1	88	77.7	41.3	148	130.7	69.5	208	183.7	97.7	268	236.6	125.8
29	25.6	13.6	89	78.6	41.8	149	131.6	70.0	209	184.5	98.1	269	237.5	126.3
30	26.5	14.1	90	79.5	42.3	150	132.4	70.4	210	185.4	98.6	270	238.4	126.8
31	27.4	14.6	91	80.3	42.7	151	133.3	70.9	211	186.3	99.1	271	239.3	127.2
32	28.3	15.0	92	81.2	43.2	152	134.2	71.4	212	187.2	99.5	272	240.2	127.7
33	29.1	15.5	93	82.1	43.7	153	135.1	71.8	213	188.1	100.0	273	241.0	128.2
34	30.0	16.0	94	83.0	44.1	154	136.0	72.3	214	189.0	100.5	274	241.9	128.6
35	30.9	16.4	95	83.9	44.6	155	136.9	72.8	215	189.8	100.9	275	242.8	129.1
36	31.8	16.9	96	84.8	45.1	156	137.7	73.2	216	190.7	101.4	276	243.7	129.6
37	32.7	17.4	97	85.6	45.5	157	138.6	73.7	217	191.6	101.9	277	244.6	130.0
38	33.6	17.8	98	86.5	46.0	158	139.5	74.2	218	192.5	102.3	278	245.5	130.5
39	34.4	18.3	99	87.4	46.5	159	140.4	74.6	219	193.4	102.8	279	246.3	131.0
40	35.3	18.8	100	88.3	46.9	160	141.3	75.1	220	194.2	103.3	280	247.2	131.5
41	36.2	19.2	101	89.2	47.4	161	142.2	75.6	221	195.1	103.8	281	248.1	131.9
42	37.1	19.7	102	90.1	47.9	162	143.0	76.1	222	196.0	104.2	282	249.0	132.4
43	38.0	20.2	103	90.9	48.4	163	143.9	76.5	223	196.9	104.7	283	249.9	132.9
44	38.8	20.7	104	91.8	48.8	164	144.8	77.0	224	197.8	105.2	284	250.8	133.3
45	39.7	21.1	105	92.7	49.3	165	145.7	77.5	225	198.7	105.6	285	251.6	133.8
46	40.6	21.6	106	93.6	49.8	166	146.6	77.9	226	199.5	106.1	286	252.5	134.3
47	41.5	22.1	107	94.5	50.2	167	147.5	78.4	227	200.4	106.6	287	253.4	134.7
48	42.4	22.5	108	95.4	50.7	168	148.3	78.9	228	201.3	107.0	288	254.3	135.2
49	43.3	23.0	109	96.2	51.2	169	149.2	79.3	229	202.2	107.5	289	255.2	135.7
50	44.1	23.5	110	97.1	51.6	170	150.1	79.8	230	203.1	108.0	290	256.1	136.1
51	45.0	23.9	111	98.0	52.1	171	151.0	80.3	231	204.0	108.4	291	256.9	136.6
52	45.9	24.4	112	98.9	52.6	172	151.9	80.7	232	204.8	108.9	292	257.8	137.1
53	46.8	24.9	113	99.8	53.1	173	152.7	81.2	233	205.7	109.4	293	258.7	137.6
54	47.7	25.4	114	100.7	53.5	174	153.6	81.7	234	206.6	109.9	294	259.6	138.0
55	48.6	25.8	115	101.5	54.0	175	154.5	82.2	235	207.5	110.3	295	260.5	138.5
56	49.4	26.3	116	102.4	54.5	176	155.4	82.6	236	208.4	110.8	296	261.3	139.0
57	50.3	26.8	117	103.3	54.9	177	156.3	83.1	237	209.3	111.3	297	262.2	139.4
58	51.2	27.2	118	104.2	55.4	178	157.2	83.6	238	210.1	111.7	298	263.1	139.9
59	52.1	27.7	119	105.1	55.9	179	158.0	84.0	239	211.0	112.2	299	264.0	140.4
60	53.0	28.2	120	106.0	56.3	180	158.9	84.5	240	211.9	112.7	300	264.9	140.8
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Difference of Latitude and Departure for 29°.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.9	00.5	61	53.4	29.6	121	105.8	58.7	181	158.3	87.8	241	210.8	116.8
2	01.7	01.0	62	54.2	30.1	122	106.7	59.1	182	159.2	88.2	242	211.7	117.3
3	02.6	01.5	63	55.1	30.5	123	107.6	59.6	183	160.1	88.7	243	212.5	117.8
4	03.5	01.9	64	56.0	31.0	124	108.5	60.1	184	160.9	89.2	244	213.4	118.3
5	04.4	02.4	65	56.9	31.5	125	109.3	60.6	185	161.8	89.7	245	214.3	118.8
6	05.2	02.9	66	57.7	32.0	126	110.2	61.1	186	162.7	90.2	246	215.2	119.3
7	06.1	03.4	67	58.6	32.5	127	111.1	61.6	187	163.6	90.7	247	216.0	119.7
8	07.0	03.9	68	59.5	33.0	128	112.0	62.1	188	164.4	91.1	248	216.9	120.2
9	07.9	04.4	69	60.3	33.5	129	112.8	62.5	189	165.3	91.6	249	217.8	120.7
10	08.7	04.8	70	61.2	33.9	130	113.7	63.0	190	166.2	92.1	250	218.7	121.2
11	09.6	05.3	71	62.1	34.4	131	114.6	63.5	191	167.1	92.6	251	219.5	121.7
12	10.5	05.8	72	63.0	34.9	132	115.4	64.0	192	167.9	93.1	252	220.4	122.2
13	11.4	06.3	73	63.8	35.4	133	116.3	64.5	193	168.8	93.6	253	221.3	122.7
14	12.2	06.8	74	64.7	35.9	134	117.2	65.0	194	169.7	94.1	254	222.2	123.1
15	13.1	07.3	75	65.6	36.4	135	118.1	65.4	195	170.6	94.5	255	223.0	123.6
16	14.0	07.8	76	66.5	36.8	136	118.9	65.9	196	171.4	95.0	256	223.9	124.1
17	14.9	08.2	77	67.3	37.3	137	119.8	66.4	197	172.3	95.5	257	224.8	124.6
18	15.7	08.7	78	68.2	37.8	138	120.7	66.9	198	173.2	96.0	258	225.7	125.1
19	16.6	09.2	79	69.1	38.3	139	121.6	67.4	199	174.0	96.5	259	226.5	125.6
20	17.5	09.7	80	70.0	38.8	140	122.4	67.9	200	174.9	97.0	260	227.4	126.1
21	18.4	10.2	81	70.8	39.3	141	123.3	68.4	201	175.8	97.4	261	228.3	126.5
22	19.2	10.7	82	71.7	39.8	142	124.2	68.8	202	176.7	97.9	262	229.2	127.0
23	20.1	11.2	83	72.6	40.2	143	125.1	69.3	203	177.5	98.4	263	230.0	127.5
24	21.0	11.6	84	73.5	40.7	144	125.9	69.8	204	178.4	98.9	264	230.9	128.0
25	21.9	12.1	85	74.3	41.2	145	126.8	70.3	205	179.3	99.4	265	231.8	128.5
26	22.7	12.6	86	75.2	41.7	146	127.7	70.8	206	180.2	99.9	266	232.6	129.0
27	23.6	13.1	87	76.1	42.2	147	128.6	71.3	207	181.0	100.4	267	233.5	129.4
28	24.5	13.6	88	77.0	42.7	148	129.4	71.8	208	181.9	100.8	268	234.4	129.9
29	25.4	14.1	89	77.8	43.1	149	130.3	72.2	209	182.8	101.3	269	235.3	130.4
30	26.2	14.5	90	78.7	43.6	150	131.2	72.7	210	183.7	101.8	270	236.1	130.9
31	27.1	15.0	91	79.6	44.1	151	132.1	73.2	211	184.5	102.3	271	237.0	131.4
32	28.0	15.5	92	80.5	44.6	152	132.9	73.7	212	185.4	102.8	272	237.9	131.9
33	28.9	16.0	93	81.3	45.1	153	133.8	74.2	213	186.3	103.3	273	238.8	132.4
34	29.7	16.5	94	82.2	45.6	154	134.7	74.7	214	187.2	103.7	274	239.6	132.8
35	30.6	17.0	95	83.1	46.1	155	135.6	75.1	215	188.0	104.2	275	240.5	133.3
36	31.5	17.5	96	84.0	46.5	156	136.4	75.6	216	188.9	104.7	276	241.4	133.8
37	32.4	17.9	97	84.8	47.0	157	137.3	76.1	217	189.8	105.2	277	242.3	134.3
38	33.2	18.4	98	85.7	47.5	158	138.2	76.6	218	190.7	105.7	278	243.1	134.8
39	34.1	18.9	99	86.6	48.0	159	139.1	77.1	219	191.5	106.2	279	244.0	135.3
40	35.0	19.4	100	87.5	48.5	160	139.9	77.6	220	192.4	106.7	280	244.9	135.7
41	35.9	19.9	101	88.3	49.0	161	140.8	78.1	221	193.3	107.1	281	245.8	136.2
42	36.7	20.4	102	89.2	49.5	162	141.7	78.5	222	194.2	107.6	282	246.6	136.7
43	37.6	20.8	103	90.1	49.9	163	142.6	79.0	223	195.0	108.1	283	247.5	137.2
44	38.5	21.3	104	91.0	50.4	164	143.4	79.5	224	195.9	108.6	284	248.4	137.7
45	39.4	21.8	105	91.8	50.9	165	144.3	80.0	225	196.8	109.1	285	249.3	138.2
46	40.2	22.3	106	92.7	51.4	166	145.2	80.5	226	197.7	109.6	286	250.1	138.7
47	41.1	22.8	107	93.6	51.9	167	146.1	81.0	227	198.5	110.1	287	251.0	139.1
48	42.0	23.3	108	94.5	52.4	168	146.9	81.4	228	199.4	110.5	288	251.9	139.6
49	42.9	23.8	109	95.3	52.8	169	147.8	81.9	229	200.3	111.0	289	252.8	140.1
50	43.7	24.2	110	96.2	53.3	170	148.7	82.4	230	201.2	111.5	290	253.6	140.6
51	44.6	24.7	111	97.1	53.8	171	149.6	82.9	231	202.0	112.0	291	254.5	141.1
52	45.5	25.2	112	98.0	54.3	172	150.4	83.4	232	202.9	112.5	292	255.4	141.6
53	46.4	25.7	113	98.8	54.8	173	151.3	83.9	233	203.8	113.0	293	256.3	142.0
54	47.2	26.2	114	99.7	55.3	174	152.2	84.4	234	204.7	113.4	294	257.1	142.5
55	48.1	26.7	115	100.6	55.8	175	153.1	84.8	235	205.5	113.9	295	258.0	143.0
56	49.0	27.1	116	101.5	56.2	176	153.9	85.3	236	206.4	114.4	296	258.9	143.5
57	49.9	27.6	117	102.3	56.7	177	154.8	85.8	237	207.3	114.9	297	259.8	144.0
58	50.7	28.1	118	103.2	57.2	178	155.7	86.3	238	208.2	115.4	298	260.6	144.5
59	51.6	28.6	119	104.1	57.7	179	156.6	86.8	239	209.0	115.9	299	261.5	145.0
60	52.5	29.1	120	105.0	58.2	180	157.4	87.3	240	209.9	116.4	300	262.4	145.4
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Difference of Latitude and Departure for 30°.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.9	00.5	61	52.8	30.5	121	104.8	60.5	181	156.8	90.5	241	208.7	120.5
2	01.7	01.0	62	53.7	31.0	122	105.7	61.0	182	157.6	91.0	242	209.6	121.0
3	02.6	01.5	63	54.6	31.5	123	106.5	61.5	183	158.5	91.5	243	210.4	121.5
4	03.5	02.0	64	55.4	32.0	124	107.4	62.0	184	159.3	92.0	244	211.3	122.0
5	04.3	02.5	65	56.3	32.5	125	108.3	62.5	185	160.2	92.5	245	212.2	122.5
6	05.2	03.0	66	57.2	33.0	126	109.1	63.0	186	161.1	93.0	246	213.0	123.0
7	06.1	03.5	67	58.0	33.5	127	110.0	63.5	187	161.9	93.5	247	213.9	123.5
8	06.9	04.0	68	58.9	34.0	128	110.9	64.0	188	162.8	94.0	248	214.8	124.0
9	07.8	04.5	69	59.8	34.5	129	111.7	64.5	189	163.7	94.5	249	215.6	124.5
10	08.7	05.0	70	60.6	35.0	130	112.6	65.0	190	164.5	95.0	250	216.5	125.0
11	09.5	05.5	71	61.5	35.5	131	113.4	65.5	191	165.4	95.5	251	217.4	125.5
12	10.4	06.0	72	62.4	36.0	132	114.3	66.0	192	166.3	96.0	252	218.2	126.0
13	11.3	06.5	73	63.2	36.5	133	115.2	66.5	193	167.1	96.5	253	219.1	126.5
14	12.1	07.0	74	64.1	37.0	134	116.0	67.0	194	168.0	97.0	254	220.0	127.0
15	13.0	07.5	75	65.0	37.5	135	116.9	67.5	195	168.9	97.5	255	220.8	127.5
16	13.9	08.0	76	65.8	38.0	136	117.8	68.0	196	169.7	98.0	256	221.7	128.0
17	14.7	08.5	77	66.7	38.5	137	118.6	68.5	197	170.6	98.5	257	222.6	128.5
18	15.6	09.0	78	67.5	39.0	138	119.5	69.0	198	171.5	99.0	258	223.4	129.0
19	16.5	09.5	79	68.4	39.5	139	120.4	69.5	199	172.3	99.5	259	224.3	129.5
20	17.3	10.0	80	69.3	40.0	140	121.2	70.0	200	173.2	100.0	260	225.2	130.0
21	18.2	10.5	81	70.1	40.5	141	122.1	70.5	201	174.1	100.5	261	226.0	130.5
22	19.1	11.0	82	71.0	41.0	142	123.0	71.0	202	174.9	101.0	262	226.9	131.0
23	19.9	11.5	83	71.9	41.5	143	123.8	71.5	203	175.8	101.5	263	227.8	131.5
24	20.8	12.0	84	72.7	42.0	144	124.7	72.0	204	176.7	102.0	264	228.6	132.0
25	21.7	12.5	85	73.6	42.5	145	125.6	72.5	205	177.5	102.5	265	229.5	132.5
26	22.5	13.0	86	74.5	43.0	146	126.4	73.0	206	178.4	103.0	266	230.4	133.0
27	23.4	13.5	87	75.3	43.5	147	127.3	73.5	207	179.3	103.5	267	231.2	133.5
28	24.2	14.0	88	76.2	44.0	148	128.2	74.0	208	180.1	104.0	268	232.1	134.0
29	25.1	14.5	89	77.1	44.5	149	129.0	74.5	209	181.0	104.5	269	233.0	134.5
30	26.0	15.0	90	77.9	45.0	150	129.9	75.0	210	181.9	105.0	270	233.8	135.0
31	26.8	15.5	91	78.8	45.5	151	130.8	75.5	211	182.7	105.5	271	234.7	135.5
32	27.7	16.0	92	79.7	46.0	152	131.6	76.0	212	183.6	106.0	272	235.6	136.0
33	28.6	16.5	93	80.5	46.5	153	132.5	76.5	213	184.5	106.5	273	236.4	136.5
34	29.4	17.0	94	81.4	47.0	154	133.4	77.0	214	185.3	107.0	274	237.3	137.0
35	30.3	17.5	95	82.3	47.5	155	134.2	77.5	215	186.2	107.5	275	238.2	137.5
36	31.2	18.0	96	83.1	48.0	156	135.1	78.0	216	187.1	108.0	276	239.0	138.0
37	32.0	18.5	97	84.0	48.5	157	136.0	78.5	217	187.9	108.5	277	239.9	138.5
38	32.9	19.0	98	84.9	49.0	158	136.8	79.0	218	188.8	109.0	278	240.8	139.0
39	33.8	19.5	99	85.7	49.5	159	137.7	79.5	219	189.7	109.5	279	241.6	139.5
40	34.6	20.0	100	86.6	50.0	160	138.6	80.0	220	190.5	110.0	280	242.5	140.0
41	35.5	20.5	101	87.5	50.5	161	139.4	80.5	221	191.4	110.5	281	243.4	140.5
42	36.4	21.0	102	88.3	51.0	162	140.3	81.0	222	192.3	111.0	282	244.2	141.0
43	37.2	21.5	103	89.2	51.5	163	141.2	81.5	223	193.1	111.5	283	245.1	141.5
44	38.1	22.0	104	90.1	52.0	164	142.0	82.0	224	194.0	112.0	284	246.0	142.0
45	39.0	22.5	105	90.9	52.5	165	142.9	82.5	225	194.9	112.5	285	246.8	142.5
46	39.8	23.0	106	91.8	53.0	166	143.8	83.0	226	195.7	113.0	286	247.7	143.0
47	40.7	23.5	107	92.7	53.5	167	144.6	83.5	227	196.6	113.5	287	248.5	143.5
48	41.6	24.0	108	93.5	54.0	168	145.5	84.0	228	197.5	114.0	288	249.4	144.0
49	42.4	24.5	109	94.4	54.5	169	146.4	84.5	229	198.3	114.5	289	250.3	144.5
50	43.3	25.0	110	95.3	55.0	170	147.2	85.0	230	199.2	115.0	290	251.1	145.0
51	44.2	25.5	111	96.1	55.5	171	148.1	85.5	231	200.1	115.5	291	252.0	145.5
52	45.0	26.0	112	97.0	56.0	172	149.0	86.0	232	200.9	116.0	292	252.9	146.0
53	45.9	26.5	113	97.9	56.5	173	149.8	86.5	233	201.8	116.5	293	253.7	146.5
54	46.8	27.0	114	98.7	57.0	174	150.7	87.0	234	202.6	117.0	294	254.6	147.0
55	47.6	27.5	115	99.6	57.5	175	151.6	87.5	235	203.5	117.5	295	255.5	147.5
56	48.5	28.0	116	100.5	58.0	176	152.4	88.0	236	204.4	118.0	296	256.3	148.0
57	49.4	28.5	117	101.3	58.5	177	153.3	88.5	237	205.2	118.5	297	257.2	148.5
58	50.2	29.0	118	102.2	59.0	178	154.2	89.0	238	206.1	119.0	298	258.1	149.0
59	51.1	29.5	119	103.1	59.5	179	155.0	89.5	239	207.0	119.5	299	258.9	149.5
60	52.0	30.0	120	103.9	60.0	180	155.9	90.0	240	207.8	120.0	300	259.8	150.0
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Difference of Latitude and Departure for 31°.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.9	00.5	61	52.3	31.4	121	103.7	62.3	181	155.1	93.2	241	206.6	124.1
2	01.7	01.0	62	53.1	31.9	122	104.6	62.8	182	156.0	93.7	242	207.4	124.6
3	02.6	01.5	63	54.0	32.4	123	105.4	63.3	183	156.9	94.3	243	208.3	125.2
4	03.4	02.1	64	54.9	33.0	124	106.3	63.9	184	157.7	94.8	244	209.1	125.7
5	04.3	02.6	65	55.7	33.5	125	107.1	64.4	185	158.6	95.3	245	210.0	126.2
6	05.1	03.1	66	56.6	34.0	126	108.0	64.9	186	159.4	95.8	246	210.9	126.7
7	06.0	03.6	67	57.4	34.5	127	108.9	65.4	187	160.3	96.3	247	211.7	127.2
8	06.9	04.1	68	58.3	35.0	128	109.7	65.9	188	161.1	96.8	248	212.6	127.7
9	07.7	04.6	69	59.1	35.5	129	110.6	66.4	189	162.0	97.3	249	213.4	128.2
10	08.6	05.2	70	60.0	36.1	130	111.4	67.0	190	162.9	97.9	250	214.3	128.8
11	09.4	05.7	71	60.9	36.6	131	112.3	67.5	191	163.7	98.4	251	215.1	129.3
12	10.3	06.2	72	61.7	37.1	132	113.1	68.0	192	164.6	98.9	252	216.0	129.8
13	11.1	06.7	73	62.6	37.6	133	114.0	68.5	193	165.4	99.4	253	216.9	130.3
14	12.0	07.2	74	63.4	38.1	134	114.9	69.0	194	166.3	99.9	254	217.7	130.8
15	12.9	07.7	75	64.3	38.6	135	115.7	69.5	195	167.1	100.4	255	218.6	131.3
16	13.7	08.2	76	65.1	39.1	136	116.6	70.0	196	168.0	100.9	256	219.4	131.8
17	14.6	08.8	77	66.0	39.7	137	117.4	70.6	197	168.9	101.5	257	220.3	132.4
18	15.4	09.3	78	66.9	40.2	138	118.3	71.1	198	169.7	102.0	258	221.1	132.9
19	16.3	09.8	79	67.7	40.7	139	119.1	71.6	199	170.6	102.5	259	222.0	133.4
20	17.1	10.3	80	68.6	41.2	140	120.0	72.1	200	171.4	103.0	260	222.9	133.9
21	18.0	10.8	81	69.4	41.7	141	120.9	72.6	201	172.3	103.5	261	223.7	134.4
22	18.9	11.3	82	70.3	42.2	142	121.7	73.1	202	173.1	104.0	262	224.6	134.9
23	19.7	11.8	83	71.1	42.7	143	122.6	73.7	203	174.0	104.6	263	225.4	135.5
24	20.6	12.4	84	72.0	43.3	144	123.4	74.2	204	174.9	105.1	264	226.3	136.0
25	21.4	12.9	85	72.9	43.8	145	124.3	74.7	205	175.7	105.6	265	227.1	136.5
26	22.3	13.4	86	73.7	44.3	146	125.1	75.2	206	176.6	106.1	266	228.0	137.0
27	23.1	13.9	87	74.6	44.8	147	126.0	75.7	207	177.4	106.6	267	228.9	137.5
28	24.0	14.4	88	75.4	45.3	148	126.9	76.2	208	178.3	107.1	268	229.7	138.0
29	24.9	14.9	89	76.3	45.8	149	127.7	76.7	209	179.1	107.6	269	230.6	138.5
30	25.7	15.5	90	77.1	46.4	150	128.6	77.3	210	180.0	108.2	270	231.4	139.1
31	26.6	16.0	91	78.0	46.9	151	129.4	77.8	211	180.9	108.7	271	232.3	139.6
32	27.4	16.5	92	78.9	47.4	152	130.3	78.3	212	181.7	109.2	272	233.1	140.1
33	28.3	17.0	93	79.7	47.9	153	131.1	78.8	213	182.6	109.7	273	234.0	140.6
34	29.1	17.5	94	80.6	48.4	154	132.0	79.3	214	183.4	110.2	274	234.9	141.1
35	30.0	18.0	95	81.4	48.9	155	132.9	79.8	215	184.3	110.7	275	235.7	141.6
36	30.9	18.5	96	82.3	49.4	156	133.7	80.3	216	185.1	111.2	276	236.6	142.2
37	31.7	19.1	97	83.1	50.0	157	134.6	80.9	217	186.0	111.8	277	237.4	142.7
38	32.6	19.6	98	84.0	50.5	158	135.4	81.4	218	186.9	112.3	278	238.3	143.2
39	33.4	20.1	99	84.9	51.0	159	136.3	81.9	219	187.7	112.8	279	239.1	143.7
40	34.3	20.6	100	85.7	51.5	160	137.1	82.4	220	188.6	113.3	280	240.0	144.2
41	35.1	21.1	101	86.6	52.0	161	138.0	82.9	221	189.4	113.8	281	240.9	144.7
42	36.0	21.6	102	87.4	52.5	162	138.9	83.4	222	190.3	114.3	282	241.7	145.2
43	36.9	22.1	103	88.3	53.0	163	139.7	84.0	223	191.1	114.9	283	242.6	145.8
44	37.7	22.7	104	89.1	53.6	164	140.6	84.5	224	192.0	115.4	284	243.4	146.3
45	38.6	23.2	105	90.0	54.1	165	141.4	85.0	225	192.9	115.9	285	244.3	146.8
46	39.4	23.7	106	90.9	54.6	166	142.3	85.5	226	193.7	116.4	286	245.1	147.3
47	40.3	24.2	107	91.7	55.1	167	143.1	86.0	227	194.6	116.9	287	246.0	147.8
48	41.1	24.7	108	92.6	55.6	168	144.0	86.5	228	195.4	117.4	288	246.9	148.3
49	42.0	25.2	109	93.4	56.1	169	144.9	87.0	229	196.3	117.9	289	247.7	148.8
50	42.9	25.8	110	94.3	56.7	170	145.7	87.6	230	197.1	118.5	290	248.6	149.4
51	43.7	26.3	111	95.1	57.2	171	146.6	88.1	231	198.0	119.0	291	249.4	149.9
52	44.6	26.8	112	96.0	57.7	172	147.4	88.6	232	198.9	119.5	292	250.3	150.4
53	45.4	27.3	113	96.9	58.2	173	148.3	89.1	233	199.7	120.0	293	251.2	150.9
54	46.3	27.8	114	97.7	58.7	174	149.1	89.6	234	200.6	120.5	294	252.0	151.4
55	47.1	28.3	115	98.6	59.2	175	150.0	90.1	235	201.4	121.0	295	252.9	151.9
56	48.0	28.8	116	99.4	59.7	176	150.9	90.6	236	202.3	121.5	296	253.7	152.5
57	48.9	29.4	117	100.3	60.3	177	151.7	91.2	237	203.1	122.1	297	254.6	153.0
58	49.7	29.9	118	101.1	60.8	178	152.6	91.7	238	204.0	122.6	298	255.4	153.5
59	50.6	30.4	119	102.0	61.3	179	153.4	92.2	239	204.9	123.1	299	256.3	154.0
60	51.4	30.9	120	102.9	61.8	180	154.3	92.7	240	205.7	123.6	300	257.1	154.5
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Difference of Latitude and Departure for 32°.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.8	00.5	61	51.7	32.3	121	102.6	64.1	181	153.5	95.9	241	204.4	127.7
2	01.7	01.1	62	52.6	32.9	122	103.5	64.7	182	154.3	96.4	242	205.2	128.2
3	02.5	01.6	63	53.4	33.4	123	104.3	65.2	183	155.2	97.0	243	206.1	128.8
4	03.4	02.1	64	54.3	33.9	124	105.2	65.7	184	156.0	97.5	244	206.9	129.3
5	04.2	02.6	65	55.1	34.4	125	106.0	66.2	185	156.9	98.0	245	207.8	129.8
6	05.1	03.2	66	56.0	35.0	126	106.9	66.8	186	157.7	98.6	246	208.6	130.4
7	05.9	03.7	67	56.8	35.5	127	107.7	67.3	187	158.6	99.1	247	209.5	130.9
8	06.8	04.2	68	57.7	36.0	128	108.6	67.8	188	159.4	99.6	248	210.3	131.4
9	07.6	04.8	69	58.5	36.6	129	109.4	68.4	189	160.3	100.2	249	211.2	131.9
10	08.5	05.3	70	59.4	37.1	130	110.2	68.9	190	161.1	100.7	250	212.0	132.5
11	09.3	05.8	71	60.2	37.6	131	111.1	69.4	191	162.0	101.2	251	212.9	133.0
12	10.2	06.4	72	61.1	38.2	132	111.9	69.9	192	162.8	101.7	252	213.7	133.5
13	11.0	06.9	73	61.9	38.7	133	112.8	70.5	193	163.7	102.3	253	214.6	134.1
14	11.9	07.4	74	62.8	39.2	134	113.6	71.0	194	164.5	102.8	254	215.4	134.6
15	12.7	07.9	75	63.6	39.7	135	114.5	71.5	195	165.4	103.3	255	216.3	135.1
16	13.6	08.5	76	64.5	40.3	136	115.3	72.1	196	166.2	103.9	256	217.1	135.7
17	14.4	09.0	77	65.3	40.8	137	116.2	72.6	197	167.1	104.4	257	217.9	136.2
18	15.3	09.5	78	66.1	41.3	138	117.0	73.1	198	167.9	104.9	258	218.8	136.7
19	16.1	10.1	79	67.0	41.9	139	117.9	73.7	199	168.8	105.5	259	219.6	137.2
20	17.0	10.6	80	67.8	42.4	140	118.7	74.2	200	169.6	106.0	260	220.5	137.8
21	17.8	11.1	81	68.7	42.9	141	119.6	74.7	201	170.5	106.5	261	221.3	138.3
22	18.7	11.7	82	69.5	43.5	142	120.4	75.2	202	171.3	107.0	262	222.2	138.8
23	19.5	12.2	83	70.4	44.0	143	121.3	75.8	203	172.2	107.6	263	223.0	139.4
24	20.4	12.7	84	71.2	44.5	144	122.1	76.3	204	173.0	108.1	264	223.9	139.9
25	21.2	13.2	85	72.1	45.0	145	123.0	76.8	205	173.8	108.6	265	224.7	140.4
26	22.0	13.8	86	72.9	45.6	146	123.8	77.4	206	174.7	109.2	266	225.6	141.0
27	22.9	14.3	87	73.8	46.1	147	124.7	77.9	207	175.5	109.7	267	226.4	141.5
28	23.7	14.8	88	74.6	46.6	148	125.5	78.4	208	176.4	110.2	268	227.3	142.0
29	24.6	15.4	89	75.5	47.2	149	126.4	79.0	209	177.2	110.8	269	228.1	142.5
30	25.4	15.9	90	76.3	47.7	150	127.2	79.5	210	178.1	111.3	270	229.0	143.1
31	26.3	16.4	91	77.2	48.2	151	128.1	80.0	211	178.9	111.8	271	229.8	143.6
32	27.1	17.0	92	78.0	48.8	152	128.9	80.5	212	179.8	112.3	272	230.7	144.1
33	28.0	17.5	93	78.9	49.3	153	129.8	81.1	213	180.6	112.9	273	231.5	144.7
34	28.8	18.0	94	79.7	49.8	154	130.6	81·6	214	181.5	113.4	274	232.4	145.2
35	29.7	18.5	95	80.6	50.3	155	131.4	82.1	215	182.3	113.9	275	233.2	145.7
36	30.5	19.1	96	81.4	50.9	156	132.3	82.7	216	183.2	114.5	276	234.1	146.3
37	31.4	19.6	97	82.3	51.4	157	133.1	83.2	217	184.0	115.0	277	234.9	146.8
38	32.2	20.1	98	83.1	51.9	158	134.0	83.7	218	184.9	115.5	278	235.8	147.3
39	33.1	20.7	99	84.0	52.5	159	134.8	84.3	219	185.7	116.1	279	236.6	147.8
40	33.9	21.2	100	84.8	53.0	160	135.7	84.8	220	186.6	116.6	280	237.5	148.4
41	34.8	21.7	101	85.7	53.5	161	136.5	85.3	221	187.4	117.1	281	238.3	148.9
42	35.6	22.3	102	86.5	54.1	162	137.4	85.8	222	188.3	117.6	282	239.1	149.4
43	36.5	22.8	103	87.3	54.6	163	138.2	86.4	223	189.1	118.2	283	240.0	150.0
44	37.3	23.3	104	88.2	55.1	164	139.1	86.9	224	190.0	118.7	284	240.8	150.5
45	38.2	23.8	105	89.0	55.6	165	139.9	87.4	225	190.8	119.2	285	241.7	151.0
46	39.0	24.4	106	89.9	56.2	166	140.8	88.0	226	191.7	119.8	286	242.5	151.6
47	39.9	24.9	107	90.7	56.7	167	141.6	88.5	227	192.5	120.3	287	243.4	152.1
48	40.7	25.4	108	91.6	57.2	168	142.5	89.0	228	193.4	120.8	288	244.2	152.6
49	41.6	26.0	109	92.4	57.8	169	143.3	89.6	229	194.2	121.4	289	245.1	153.1
50	42.4	26.5	110	93.3	58.3	170	144.2	90.1	230	195.1	121.9	290	245.9	153.7
51	43.3	27.0	111	94.1	58.8	171	145.0	90.6	231	195.9	122.4	291	246.8	154.2
52	44.1	27.6	112	95.0	59.4	172	145.9	91.1	232	196.7	122.9	292	247.6	154.7
53	44.9	28.1	113	95.8	59.9	173	146.7	91.7	233	197.6	123.5	293	248.5	155.3
54	45.8	28.6	114	96.7	60.4	174	147.6	92.2	234	198.4	124.0	294	249.3	155.8
55	46.6	29.1	115	97.5	60.9	175	148.4	92.7	235	199.3	124.5	295	250.2	156.3
56	47.5	29.7	116	98.4	61.5	176	149.3	93.3	236	200.1	125.1	296	251.0	156.9
57	48.3	30.2	117	99.2	62.0	177	150.1	93.8	237	201.0	125.6	297	251.9	157.4
58	49.2	30.7	118	100.1	62.5	178	151.0	94.3	238	201.8	126.1	298	252.7	157.9
59	50.0	31.3	119	100.9	63.1	179	151.8	94.9	239	202.7	126.7	299	253.6	158.4
60	50.9	31.8	120	101.8	63.6	180	152.6	95.4	240	203.5	127.2	300	254.4	159.0
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Difference of Latitude and Departure for 33°.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Lep.
1	00.8	00.5	61	51.2	33.2	121	101.5	65.9	181	151.8	98.6	241	202.1	131.3
2	01.7	01.1	62	52.0	33.8	122	102.3	66.4	182	152.6	99.1	242	203.0	131.8
3	02.5	01.6	63	52.8	34.3	123	103.2	67.0	183	153.5	99.7	243	203.8	132.3
4	03.4	02.2	64	53.7	34.9	124	104.0	67.5	184	154.3	100.2	244	204.6	132.9
5	04.2	02.7	65	54.5	35.4	125	104.8	68.1	185	155.2	100.8	245	205.5	133.4
6	05.0	03.3	66	55.4	35.9	126	105.7	68.6	186	156.0	101.3	246	206.3	134.0
7	05.9	03.8	67	56.2	36.5	127	106.5	69.2	187	156.8	101.8	247	207.2	134.5
8	06.7	04.4	68	57.0	37.0	128	107.3	69.7	188	157.7	102.4	248	208.0	135.1
9	07.5	04.9	69	57.9	37.6	129	108.2	70.3	189	158.5	102.9	249	208.8	135.6
10	08.4	05.4	70	58.7	38.1	130	109.0	70.8	190	159.3	103.5	250	209.7	136.2
11	09.2	06.0	71	59.5	38.7	131	109.9	71.3	191	160.2	104.0	251	210.5	136.7
12	10.1	06.5	72	60.4	39.2	132	110.7	71.9	192	161.0	104.6	252	211.3	137.2
13	10.9	07.1	73	61.2	39.8	133	111.5	72.4	193	161.9	105.1	253	212.2	137.8
14	11.7	07.6	74	62.1	40.3	134	112.4	73.0	194	162.7	105.7	254	213.0	138.3
15	12.6	08.2	75	62.9	40.8	135	113.2	73.5	195	163.5	106.2	255	213.9	138.9
16	13.4	08.7	76	63.7	41.4	136	114.1	74.1	196	164.4	106.7	256	214.7	139.4
17	14.3	09.3	77	64.6	41.9	137	114.9	74.6	197	165.2	107.3	257	215.5	140.0
18	15.1	09.8	78	65.4	42.5	138	115.7	75.2	198	166.1	107.8	258	216.4	140.5
19	15.9	10.3	79	66.3	43.0	139	116.6	75.7	199	166.9	108.4	259	217.2	141.1
20	16.8	10.9	80	67.1	43.6	140	117.4	76.2	200	167.7	108.9	260	218.1	141.6
21	17.6	11.4	81	67.9	44.1	141	118.3	76.8	201	168.6	109.5	261	218.9	142.2
22	18.5	12.0	82	68.8	44.7	142	119.1	77.3	202	169.4	110.0	262	219.7	142.7
23	19.3	12.5	83	69.6	45.2	143	119.9	77.9	203	170.3	110.6	263	220.6	143.2
24	20.1	13.1	84	70.4	45.7	144	120.8	78.4	204	171.1	111.1	264	221.4	143.8
25	21.0	13.6	85	71.3	46.3	145	121.6	79.0	205	171.9	111.7	265	222.2	144.3
26	21.8	14.2	86	72.1	46.8	146	122.4	79.5	206	172.8	112.2	266	223.1	144.9
27	22.6	14.7	87	73.0	47.4	147	123.3	80.1	207	173.6	112.7	267	223.9	145.4
28	23.5	15.2	88	73.8	47.9	148	124.1	80.6	208	174.4	113.3	268	224.8	146.0
29	24.3	15.8	89	74.6	48.5	149	125.0	81.2	209	175.3	113.8	269	225.6	146.5
30	25.2	16.3	90	75.5	49.0	150	125.8	81.7	210	176.1	114.4	270	226.4	147.1
31	26.0	16.9	91	76.3	49.6	151	126.6	82.2	211	177.0	114.9	271	227.3	147.6
32	26.8	17.4	92	77.2	50.1	152	127.5	82.8	212	177.8	115.5	272	228.1	148.1
33	27.7	18.0	93	78.0	50.7	153	128.3	83.3	213	178.6	116.0	273	229.0	148.7
34	28.5	18.5	94	78.8	51.2	154	129.2	83.9	214	179.5	116.6	274	229.8	149.2
35	29.4	19.1	95	79.7	51.7	155	130.0	84.4	215	180.3	117.1	275	230.6	149.8
36	30.2	19.6	96	80.5	52.3	156	130.8	85.0	216	181.2	117.6	276	231.5	150.3
37	31.0	20.2	97	81.4	52.8	157	131.7	85.5	217	182.0	118.2	277	232.3	150.9
38	31.9	20.7	98	82.2	53.4	158	132.5	86.1	218	182.8	118.7	278	233.2	151.4
39	32.7	21.2	99	83.0	53.9	159	133.3	86.6	219	183.7	119.3	279	234.0	152.0
40	33.5	21.8	100	83.9	54.5	160	134.2	87.1	220	184.5	119.8	280	234.8	152.5
41	34.4	22.3	101	84.7	55.0	161	135.0	87.7	221	185.3	120.4	281	235.7	153.0
42	35.2	22.9	102	85.5	55.6	162	135.9	88.2	222	186.2	120.9	282	236.5	153.6
43	36.1	23.4	103	86.4	56.1	163	136.7	88.8	223	187.0	121.5	283	237.3	154.1
44	36.9	24.0	104	87.2	56.6	164	137.5	89.3	224	187.9	122.0	284	238.2	154.7
45	37.7	24.5	105	88.1	57.2	165	138.4	89.9	225	188.7	122.5	285	239.0	155.2
46	38.6	25.1	106	88.9	57.7	166	139.2	90.4	226	189.5	123.1	286	239.9	155.8
47	39.4	25.6	107	89.7	58.3	167	140.1	91.0	227	190.4	123.6	287	240.7	156.3
48	40.3	26.1	108	90.6	58.8	168	140.9	91.5	228	191.2	124.2	288	241.5	156.9
49	41.1	26.7	109	91.4	59.4	169	141.7	92.0	229	192.1	124.7	289	242.4	157.4
50	41.9	27.2	110	92.3	59.9	170	142.6	92.6	230	192.9	125.3	290	243.2	157.9
51	42.8	27.8	111	93.1	60.5	171	143.4	93.1	231	193.7	125.8	291	244.1	158.5
52	43.6	28.3	112	93.9	61.0	172	144.3	93.7	232	194.6	126.4	292	244.9	159.0
53	44.4	28.9	113	94.8	61.5	173	145.1	94.2	233	195.4	126.9	293	245.7	159.6
54	45.3	29.4	114	95.6	62.1	174	145.9	94.8	234	196.2	127.4	294	246.6	160.1
55	46.1	30.0	115	96.4	62.6	175	146.8	95.3	235	197.1	128.0	295	247.4	160.7
56	47.0	30.5	116	97.3	63.2	176	147.6	95.9	236	197.9	128.5	296	248.2	161.2
57	47.8	31.0	117	98.1	63.7	177	148.4	96.4	237	198.8	129.1	297	249.1	161.8
58	48.6	31.6	118	99.0	64.3	178	149.3	96.9	238	199.6	129.6	298	249.9	162.3
59	49.5	32.1	119	99.8	64.8	179	150.1	97.5	239	200.4	130.2	299	250.8	162.8
60	50.3	32.7	120	100.6	65.4	180	151.0	98.0	240	201.3	130.7	300	251.6	163.4
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Difference of Latitude and Departure for 34°.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.8	00.6	61	50.6	34.1	121	100.3	67.7	181	150.1	101.2	241	199.8	134.8
2	01.7	01.1	62	51.4	34.7	122	101.1	68.2	182	150.9	101.8	242	200.6	135.3
3	02.5	01.7	63	52.2	35.2	123	102.0	68.8	183	151.7	102.3	243	201.5	135.9
4	03.3	02.2	64	53.1	35.8	124	102.8	69.3	184	152.5	102.9	244	202.3	136.4
5	04.1	02.8	65	53.9	36.3	125	103.6	69.9	185	153.4	103.5	245	203.1	137.0
6	05.0	03.4	66	54.7	36.9	126	104.5	70.5	186	154.2	104.0	246	203.9	137.6
7	05.8	03.9	67	55.5	37.5	127	105.3	71.0	187	155.0	104.6	247	204.8	138.1
8	06.6	04.5	68	56.4	38.0	128	106.1	71.6	188	155.9	105.1	248	205.6	138.7
9	07.5	05.0	69	57.2	38.6	129	106.9	72.1	189	156.7	105.7	249	206.4	139.2
10	08.3	05.6	70	58.0	39.1	130	107.8	72.7	190	157.5	106.2	250	207.3	139.8
11	09.1	06.2	71	58.9	39.7	131	108.6	73.3	191	158.3	106.8	251	208.1	140.4
12	09.9	06.7	72	59.7	40.3	132	109.4	73.8	192	159.2	107.4	252	208.9	140.9
13	10.8	07.3	73	60.5	40.8	133	110.3	74.4	193	160.0	107.9	253	209.7	141.5
14	11.6	07.8	74	61.3	41.4	134	111.1	74.9	194	160.8	108.5	254	210.6	142.0
15	12.4	08.4	75	62.2	41.9	135	111.9	75.5	195	161.7	109.0	255	211.4	142.6
16	13.3	08.9	76	63.0	42.5	136	112.7	76.1	196	162.5	109.6	256	212.2	143.2
17	14.1	09.5	77	63.8	43.1	137	113.6	76.6	197	163.3	110.2	257	213.1	143.7
18	14.9	10.1	78	64.7	43.6	138	114.4	77.2	198	164.1	110.7	258	213.9	144.3
19	15.8	10.6	79	65.5	44.2	139	115.2	77.7	199	165.0	111.3	259	214.7	144.8
20	16.6	11.2	80	66.3	44.7	140	116.1	78.3	200	165.8	111.8	260	215.5	145.4
21	17.4	11.7	81	67.2	45.3	141	116.9	78.8	201	166.6	112.4	261	216.4	145.9
22	18.2	12.3	82	68.0	45.9	142	117.7	79.4	202	167.5	113.0	262	217.2	146.5
23	19.1	12.9	83	68.8	46.4	143	118.6	80.0	203	168.3	113.5	263	218.0	147.1
24	19.9	13.4	84	69.6	47.0	144	119.4	80.5	204	169.1	114.1	264	218.9	147.6
25	20.7	14.0	85	70.5	47.5	145	120.2	81.1	205	170.0	114.6	265	219.7	148.2
26	21.6	14.5	86	71.3	48.1	146	121.0	81.6	206	170.8	115.2	266	220.5	148.7
27	22.4	15.1	87	72.1	48.6	147	121.9	82.2	207	171.6	115.8	267	221.4	149.3
28	23.2	15.7	88	73.0	49.2	148	122.7	82.8	208	172.4	116.3	268	222.2	149.9
29	24.0	16.2	89	73.8	49.8	149	123.5	83.3	209	173.3	116.9	269	223.0	150.4
30	24.9	16.8	90	74.6	50.3	150	124.4	83.9	210	174.1	117.4	270	223.8	151.0
31	25.7	17.3	91	75.4	50.9	151	125.2	84.4	211	174.9	118.0	271	224.7	151.5
32	26.5	17.9	92	76.3	51.4	152	126.0	85.0	212	175.8	118.5	272	225.5	152.1
33	27.4	18.5	93	77.1	52.0	153	126.8	85.6	213	176.6	119.1	273	226.3	152.7
34	28.2	19.0	94	77.9	52.6	154	127.7	86.1	214	177.4	119.7	274	227.2	153.2
35	29.0	19.6	95	78.8	53.1	155	128.5	86.7	215	178.2	120.2	275	228.0	153.8
36	29.8	20.1	96	79.6	53.7	156	129.3	87.2	216	179.1	120.8	276	228.8	154.3
37	30.7	20.7	97	80.4	54.2	157	130.2	87.8	217	179.9	121.3	277	229.6	154.9
38	31.5	21.2	98	81.2	54.8	158	131.0	88.4	218	180.7	121.9	278	230.5	155.5
39	32.3	21.8	99	82.1	55.4	159	131.8	88.9	219	181.6	122.5	279	231.3	156.0
40	33.2	22.4	100	82.9	55.9	160	132.6	89.5	220	182.4	123.0	280	232.1	156.6
41	34.0	22.9	101	83.7	56.5	161	133.5	90.0	221	183.2	123.6	281	233.0	157.1
42	34.8	23.5	102	84.6	57.0	162	134.3	90.6	222	184.0	124.1	282	233.8	157.7
43	35.6	24.0	103	85.4	57.6	163	135.1	91.1	223	184.9	124.7	283	234.6	158.3
44	36.5	24.6	104	86.2	58.2	164	136.0	91.7	224	185.7	125.3	284	235.4	158.8
45	37.3	25.2	105	87.0	58.7	165	136.8	92.3	225	186.5	125.8	285	236.3	159.4
46	38.1	25.7	106	87.9	59.3	166	137.6	92.8	226	187.4	126.4	286	237.1	159.9
47	39.0	26.3	107	88.7	59.8	167	138.4	93.4	227	188.2	126.9	287	237.9	160.5
48	39.8	26.8	108	89.5	60.4	168	139.3	93.9	228	189.0	127.5	288	238.8	161.0
49	40.6	27.4	109	90.4	61.0	169	140.1	94.5	229	189.8	128.1	289	239.6	161.6
50	41.5	28.0	110	91.2	61.5	170	140.9	95.1	230	190.7	128.6	290	240.4	162.2
51	42.3	28.5	111	92.0	62.1	171	141.8	95.6	231	191.5	129.2	291	241.2	162.7
52	43.1	29.1	112	92.9	62.6	172	142.6	96.2	232	192.3	129.7	292	242.1	163.3
53	43.9	29.6	113	93.7	63.2	173	143.4	96.7	233	193.2	130.3	293	242.9	163.8
54	44.8	30.2	114	94.5	63.7	174	144.3	97.3	234	194.0	130.9	294	243.7	164.4
55	45.6	30.8	115	95.3	64.3	175	145.1	97.9	235	194.8	131.4	295	244.6	165.0
56	46.4	31.3	116	96.2	64.9	176	145.9	98.4	236	195.7	132.0	296	245.4	165.5
57	47.3	31.9	117	97.0	65.4	177	146.7	99.0	237	196.5	132.5	297	246.2	166.1
58	48.1	32.4	118	97.8	66.0	178	147.6	99.5	238	197.3	133.1	298	247.1	166.6
59	48.9	33.0	119	98.7	66.5	179	148.4	100.1	239	198.1	133.6	299	247.9	167.2
60	49.7	33.6	120	99.5	67.1	180	149.2	100.7	240	199.0	134.2	300	248.7	167.8
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Difference of Latitude and Departure for 35°.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.8	00.6	61	50.0	35.0	121	99.1	69.4	181	148.3	103.8	241	197.4	138.2
2	01.6	01.1	62	50.8	35.6	122	99.9	70.0	182	149.1	104.4	242	198.2	138.8
3	02.5	01.7	63	51.6	36.1	123	100.8	70.5	183	149.9	105.0	243	199.1	139.4
4	03.3	02.3	64	52.4	36.7	124	101.6	71.1	184	150.7	105.5	244	199.9	140.0
5	04.1	02.9	65	53.2	37.3	125	102.4	71.7	185	151.5	106.1	245	200.7	140.5
6	04.9	03.4	66	54.1	37.9	126	103.2	72.3	186	152.4	106.7	246	201.5	141.1
7	05.7	04.0	67	54.9	38.4	127	104.0	72.8	187	153.2	107.3	247	202.3	141.7
8	06.6	04.6	68	55.7	39.0	128	104.9	73.4	188	154.0	107.8	248	203.1	142.2
9	07.4	05.2	69	56.5	39.6	129	105.7	74.0	189	154.8	108.4	249	204.0	142.8
10	08.2	05.7	70	57.3	40.2	130	106.5	74.6	190	155.6	109.0	250	204.8	143.4
11	09.0	06.3	71	58.2	40.7	131	107.3	75.1	191	156.5	109.6	251	205.6	144.0
12	09.8	06.9	72	59.0	41.3	132	108.1	75.7	192	157.3	110.1	252	206.4	144.5
13	10.6	07.5	73	59.8	41.9	133	108.9	76.3	193	158.1	110.7	253	207.2	145.1
14	11.5	08.0	74	60.6	42.4	134	109.8	76.9	194	158.9	111.3	254	208.1	145.7
15	12.3	08.6	75	61.4	43.0	135	110.6	77.4	195	159.7	111.8	255	208.9	146.3
16	13.1	09.2	76	62.3	43.6	136	111.4	78.0	196	160.6	112.4	256	209.7	146.8
17	13.9	09.8	77	63.1	44.2	137	112.2	78.6	197	161.4	113.0	257	210.5	147.4
18	14.7	10.3	78	63.9	44.7	138	113.0	79.2	198	162.2	113.6	258	211.3	148.0
19	15.6	10.9	79	64.7	45.3	139	113.9	79.7	199	163.0	114.1	259	212.2	148.6
20	16.4	11.5	80	65.5	45.9	140	114.7	80.3	200	163.8	114.7	260	213.0	149.1
21	17.2	12.0	81	66.4	46.5	141	115.5	80.9	201	164.6	115.3	261	213.8	149.7
22	18.0	12.6	82	67.2	47.0	142	116.3	81.4	202	165.5	115.9	262	214.6	150.3
23	18.8	13.2	83	68.0	47.6	143	117.1	82.0	203	166.3	116.4	263	215.4	150.9
24	19.7	13.8	84	68.8	48.2	144	118.0	82.6	204	167.1	117.0	264	216.3	151.4
25	20.5	14.3	85	69.6	48.8	145	118.8	83.2	205	167.9	117.6	265	217.1	152.0
26	21.3	14.9	86	70.4	49.3	146	119.6	83.7	206	168.7	118.2	266	217.9	152.6
27	22.1	15.5	87	71.3	49.9	147	120.4	84.3	207	169.6	118.7	267	218.7	153.1
28	22.9	16.1	88	72.1	50.5	148	121.2	84.9	208	170.4	119.3	268	219.5	153.7
29	23.8	16.6	89	72.9	51.0	149	122.1	85.5	209	171.2	119.9	269	220.4	154.3
30	24.6	17.2	90	73.7	51.6	150	122.9	86.0	210	172.0	120.5	270	221.2	154.9
31	25.4	17.8	91	74.5	52.2	151	123.7	86.6	211	172.8	121.0	271	222.0	155.4
32	26.2	18.4	92	75.4	52.8	152	124.5	87.2	212	173.7	121.6	272	222.8	156.0
33	27.0	18.9	93	76.2	53.3	153	125.3	87.8	213	174.5	122.2	273	223.6	156.6
34	27.9	19.5	94	77.0	53.9	154	126.1	88.3	214	175.3	122.7	274	224.4	157.2
35	28.7	20.1	95	77.8	54.5	155	127.0	88.9	215	176.1	123.3	275	225.3	157.7
36	29.5	20.6	96	78.6	55.1	156	127.8	89.5	216	176.9	123.9	276	226.1	158.3
37	30.3	21.2	97	79.5	55.6	157	128.6	90.1	217	177.8	124.5	277	226.9	158.9
38	31.1	21.8	98	80.3	56.2	158	129.4	90.6	218	178.6	125.0	278	227.7	159.5
39	31.9	22.4	99	81.1	56.8	159	130.2	91.2	219	179.4	125.6	279	228.5	160.0
40	32.8	22.9	100	81.9	57.4	160	131.1	91.8	220	180.2	126.2	280	229.4	160.6
41	33.6	23.5	101	82.7	57.9	161	131.9	92.3	221	181.0	126.8	281	230.2	161.2
42	34.4	24.1	102	83.6	58.5	162	132.7	92.9	222	181.9	127.3	282	231.0	161.7
43	35.2	24.7	103	84.4	59.1	163	133.5	93.5	223	182.7	127.9	283	231.8	162.3
44	36.0	25.2	104	85.2	59.7	164	134.3	94.1	224	183.5	128.5	284	232.6	162.9
45	36.9	25.8	105	86.0	60.2	165	135.2	94.6	225	184.3	129.1	285	233.5	163.5
46	37.7	26.4	106	86.8	60.8	166	136.0	95.2	226	185.1	129.6	286	234.3	164.0
47	38.5	27.0	107	87.6	61.4	167	136.8	95.8	227	185.9	130.2	287	235.1	164.6
48	39.3	27.5	108	88.5	61.9	168	137.6	96.4	228	186.8	130.8	288	235.9	165.2
49	40.1	28.1	109	89.3	62.5	169	138.4	96.9	229	187.6	131.3	289	236.7	165.8
50	41.0	28.7	110	90.1	63.1	170	139.3	97.5	230	188.4	131.9	290	237.6	166.3
51	41.8	29.3	111	90.9	63.7	171	140.1	98.1	231	189.2	132.5	291	238.4	166.9
52	42.6	29.8	112	91.7	64.2	172	140.9	98.7	232	190.0	133.1	292	239.2	167.5
53	43.4	30.4	113	92.6	64.8	173	141.7	99.2	233	190.9	133.6	293	240.0	168.1
54	44.2	31.0	114	93.4	65.4	174	142.5	99.8	234	191.7	134.2	294	240.8	168.6
55	45.1	31.5	115	94.2	66.0	175	143.4	100.4	235	192.5	134.8	295	241.6	169.2
56	45.9	32.1	116	95.0	66.5	176	144.2	100.9	236	193.3	135.4	296	242.5	169.8
57	46.7	32.7	117	95.8	67.1	177	145.0	101.5	237	194.1	135.9	297	243.3	170.4
58	47.5	33.3	118	96.7	67.7	178	145.8	102.1	238	195.0	136.5	298	244.1	170.9
59	48.3	33.8	119	97.5	68.3	179	146.6	102.7	239	195.8	137.1	299	244.9	171.5
60	49.1	34.4	120	98.3	68.8	180	147.4	103.2	240	196.6	137.7	300	245.7	172.1
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Difference of Latitude and Departure for 36°.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.8	00.6	61	49.4	35.9	121	97.9	71.1	181	146.4	106.4	241	195.0	141.7
2	01.6	01.2	62	50.2	36.4	122	98.7	71.7	182	147.2	107.0	242	195.8	142.2
3	02.4	01.8	63	51.0	37.0	123	99.5	72.3	183	148.1	107.6	243	196.6	142.8
4	03.2	02.4	64	51.8	37.6	124	100.3	72.9	184	148.9	108.2	244	197.4	143.4
5	04.0	02.9	65	52.6	38.2	125	101.1	73.5	185	149.7	108.7	245	198.2	144.0
6	04.9	03.5	66	53.4	38.8	126	101.9	74.1	186	150.5	109.3	246	199.0	144.6
7	05.7	04.1	67	54.2	39.4	127	102.7	74.6	187	151.3	109.9	247	199.8	145.2
8	06.5	04.7	68	55.0	40.0	128	103.6	75.2	188	152.1	110.5	248	200.6	145.8
9	07.3	05.3	69	55.8	40.6	129	104.4	75.8	189	152.9	111.1	249	201.4	146.4
10	08.1	05.9	70	56.6	41.1	130	105.2	76.4	190	153.7	111.7	250	202.3	146.9
11	08.9	06.5	71	57.4	41.7	131	106.0	77.0	191	154.5	112.3	251	203.1	147.5
12	09.7	07.1	72	58.2	42.3	132	106.8	77.6	192	155.3	112.9	252	203.9	148.1
13	10.5	07.6	73	59.1	42.9	133	107.6	78.2	193	156.1	113.4	253	204.7	148.7
14	11.3	08.2	74	59.9	43.5	134	108.4	78.8	194	156.9	114.0	254	205.5	149.3
15	12.1	08.8	75	60.7	44.1	135	109.2	79.4	195	157.8	114.6	255	206.3	149.9
16	12.9	09.4	76	61.5	44.7	136	110.0	79.9	196	158.6	115.2	256	207.1	150.5
17	13.8	10.0	77	62.3	45.3	137	110.8	80.5	197	159.4	115.8	257	207.9	151.1
18	14.6	10.6	78	63.1	45.8	138	111.6	81.0	198	160.2	116.4	258	208.7	151.6
19	15.4	11.2	79	63.9	46.4	139	112.5	81.7	199	161.0	117.0	259	209.5	152.2
20	16.2	11.8	80	64.7	47.0	140	113.3	82.3	200	161.8	117.6	260	210.3	152.8
21	17.0	12.3	81	65.5	47.6	141	114.1	82.9	201	162.6	118.1	261	211.2	153.4
22	17.8	12.9	82	66.3	48.2	142	114.9	83.5	202	163.4	118.7	262	212.0	154.0
23	18.6	13.5	83	67.1	48.8	143	115.7	84.1	203	164.2	119.3	263	212.8	154.6
24	19.4	14.1	84	68.0	49.4	144	116.5	84.6	204	165.0	119.9	264	213.6	155.2
25	20.2	14.7	85	68.8	50.0	145	117.3	85.2	205	165.8	120.5	265	214.4	155.8
26	21.0	15.3	86	69.6	50.5	146	118.1	85.8	206	166.7	121.1	266	215.2	156.4
27	21.8	15.9	87	70.4	51.1	147	118.9	86.4	207	167.5	121.7	267	216.0	156.9
28	22.7	16.5	88	71.2	51.7	148	119.7	87.0	208	168.3	122.3	268	216.8	157.5
29	23.5	17.0	89	72.0	52.3	149	120.5	87.6	209	169.1	122.8	269	217.6	158.1
30	24.3	17.6	90	72.8	52.9	150	121.4	88.2	210	169.9	123.4	270	218.4	158.7
31	25.1	18.2	91	73.6	53.5	151	122.2	88.8	211	170.7	124.0	271	219.2	159.3
32	25.9	18.8	92	74.4	54.1	152	123.0	89.3	212	171.5	124.6	272	220.1	159.9
33	26.7	19.4	93	75.2	54.7	153	123.8	89.9	213	172.3	125.2	273	220.9	160.5
34	27.5	20.0	94	76.0	55.3	154	124.6	90.5	214	173.1	125.8	274	221.7	161.1
35	28.3	20.6	95	76.9	55.8	155	125.4	91.1	215	173.9	126.4	275	222.5	161.6
36	29.1	21.2	96	77.7	56.4	156	126.2	91.7	216	174.7	127.0	276	223.3	162.2
37	29.9	21.7	97	78.5	57.0	157	127.0	92.3	217	175.6	127.5	277	224.1	162.8
38	30.7	22.3	98	79.3	57.6	158	127.8	92.9	218	176.4	128.1	278	224.9	163.4
39	31.6	22.9	99	80.1	58.2	159	128.6	93.5	219	177.2	128.7	279	225.7	164.0
40	32.4	23.5	100	80.9	58.8	160	129.4	94.0	220	178.0	129.3	280	226.5	164.6
41	33.2	24.1	101	81.7	59.4	161	130.3	94.6	221	178.8	129.9	281	227.3	165.2
42	34.0	24.7	102	82.5	60.0	162	131.1	95.2	222	179.6	130.5	282	228.1	165.8
43	34.8	25.3	103	83.3	60.5	163	131.9	95.8	223	180.4	131.1	283	229.0	166.3
44	35.6	25.9	104	84.1	61.1	164	132.7	96.4	224	181.2	131.7	284	229.8	166.9
45	36.4	26.5	105	84.9	61.7	165	133.5	97.0	225	182.0	132.3	285	230.6	167.5
46	37.2	27.0	106	85.8	62.3	166	134.3	97.6	226	182.8	132.8	286	231.4	168.1
47	38.0	27.6	107	86.6	62.9	167	135.1	98.2	227	183.6	133.4	287	232.2	168.7
48	38.8	28.2	108	87.4	63.5	168	135.9	98.7	228	184.5	134.0	288	233.0	169.3
49	39.6	28.8	109	88.2	64.1	169	136.7	99.3	229	185.3	134.6	289	233.8	169.9
50	40.5	29.4	110	89.0	64.7	170	137.5	99.9	230	186.1	135.2	290	234.6	170.5
51	41.3	30.0	111	89.8	65.2	171	138.3	100.5	231	186.9	135.8	291	235.4	171.0
52	42.1	30.6	112	90.6	65.8	172	139.2	101.1	232	187.7	136.4	292	236.2	171.6
53	42.9	31.2	113	91.4	66.4	173	140.0	101.7	233	188.5	137.0	293	237.0	172.2
54	43.7	31.7	114	92.2	67.0	174	140.8	102.3	234	189.3	137.5	294	237.9	172.8
55	44.5	32.3	115	93.0	67.6	175	141.6	102.9	235	190.1	138.1	295	238.7	173.4
56	45.3	32.9	116	93.8	68.2	176	142.4	103.5	236	190.9	138.7	296	239.5	174.0
57	46.1	33.5	117	94.7	68.8	177	143.2	104.0	237	191.7	139.3	297	240.3	174.6
58	46.9	34.1	118	95.5	69.4	178	144.0	104.6	238	192.5	139.9	298	241.1	175.2
59	47.7	34.7	119	96.3	69.9	179	144.8	105.2	239	193.4	140.5	299	241.9	175.7
60	48.5	35.3	120	97.1	70.5	180	145.6	105.8	240	194.2	141.1	300	242.7	176.3
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Difference of Latitude and Departure for 37°.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.8	00.6	61	48.7	36.7	121	96.6	72.8	181	144.6	108.9	241	192.5	145.0
2	01.6	01.2	62	49.5	37.3	122	97.4	73.4	182	145.4	109.5	242	193.3	145.6
3	02.4	01.8	63	50.3	37.9	123	98.2	74.0	183	146.2	110.1	243	194.1	146.2
4	03.2	02.4	64	51.1	38.5	124	99.0	74.6	184	146.9	110.7	244	194.9	146.8
5	04.0	03.0	65	51.9	39.1	125	99.8	75.2	185	147.7	111.3	245	195.7	147.4
6	04.8	03.6	66	52.7	39.7	126	100.6	75.8	186	148.5	111.9	246	196.5	148.0
7	05.6	04.2	67	53.5	40.3	127	101.4	76.4	187	149.3	112.5	247	197.3	148.6
8	06.4	04.8	68	54.3	40.9	128	102.2	77.0	188	150.1	113.1	248	198.1	149.3
9	07.2	05.4	69	55.1	41.5	129	103.0	77.6	189	150.9	113.7	249	198.9	149.9
10	08.0	06.0	70	55.9	42.1	130	103.8	78.2	190	151.7	114.3	250	199.7	150.5
11	08.8	06.6	71	56.7	42.7	131	104.6	78.8	191	152.5	114.9	251	200.5	151.1
12	09.6	07.2	72	57.5	43.3	132	105.4	79.4	192	153.3	115.5	252	201.3	151.7
13	10.4	07.8	73	58.3	43.9	133	106.2	80.0	193	154.1	116.2	253	202.1	152.3
14	11.2	08.4	74	59.1	44.5	134	107.0	80.6	194	154.9	116.8	254	202.9	152.9
15	12.0	09.0	75	59.9	45.1	135	107.8	81.2	195	155.7	117.4	255	203.7	153.5
16	12.8	09.6	76	60.7	45.7	136	108.6	81.8	196	156.5	118.0	256	204.5	154.1
17	13.6	10.2	77	61.5	46.3	137	109.4	82.4	197	157.3	118.6	257	205.2	154.7
18	14.4	10.8	78	62.3	46.9	138	110.2	83.1	198	158.1	119.2	258	206.0	155.3
19	15.2	11.4	79	63.1	47.5	139	111.0	83.7	199	158.9	119.8	259	206.8	155.9
20	16.0	12.0	80	63.9	48.1	140	111.8	84.3	200	159.7	120.4	260	207.6	156.5
21	16.8	12.6	81	64.7	48.7	141	112.6	84.9	201	160.5	121.0	261	208.4	157.1
22	17.6	13.2	82	65.5	49.3	142	113.4	85.5	202	161.3	121.6	262	209.2	157.7
23	18.4	13.8	83	66.3	50.0	143	114.2	86.1	203	162.1	122.2	263	210.0	158.3
24	19.2	14.4	84	67.1	50.6	144	115.0	86.7	204	162.9	122.8	264	210.8	158.9
25	20.0	15.0	85	67.9	51.2	145	115.8	87.3	205	163.7	123.4	265	211.6	159.5
26	20.8	15.6	86	68.7	51.8	146	116.6	87.9	206	164.5	124.0	266	212.4	160.1
27	21.6	16.2	87	69.5	52.4	147	117.4	88.5	207	165.3	124.6	267	213.2	160.7
28	22.4	16.9	88	70.3	53.0	148	118.2	89.1	208	166.1	125.2	268	214.0	161.3
29	23.2	17.5	89	71.1	53.6	149	119.0	89.7	209	166.9	125.8	269	214.8	161.9
30	24.0	18.1	90	71.9	54.2	150	119.8	90.3	210	167.7	126.4	270	215.6	162.5
31	24.8	18.7	91	72.7	54.8	151	120.6	90.9	211	168.5	127.0	271	216.4	163.1
32	25.6	19.3	92	73.5	55.4	152	121.4	91.5	212	169.3	127.6	272	217.2	163.7
33	26.4	19.9	93	74.3	56.0	153	122.2	92.1	213	170.1	128.2	273	218.0	164.3
34	27.2	20.5	94	75.1	56.6	154	123.0	92.7	214	170.9	128.8	274	218.8	164.9
35	28.0	21.1	95	75.9	57.2	155	123.8	93.3	215	171.7	129.4	275	219.6	165.5
36	28.8	21.7	96	76.7	57.8	156	124.6	93.9	216	172.5	130.0	276	220.4	166.1
37	29.5	22.3	97	77.5	58.4	157	125.4	94.5	217	173.3	130.6	277	221.2	166.7
38	30.3	22.9	98	78.3	59.0	158	126.2	95.1	218	174.1	131.2	278	222.0	167.3
39	31.1	23.5	99	79.1	59.6	159	127.0	95.7	219	174.9	131.8	279	222.8	167.9
40	31.9	24.1	100	79.9	60.2	160	127.8	96.3	220	175.7	132.4	280	223.6	168.5
41	32.7	24.7	101	80.7	60.8	161	128.6	96.9	221	176.5	133.0	281	224.4	169.1
42	33.5	25.3	102	81.5	61.4	162	129.4	97.5	222	177.3	133.6	282	225.2	169.7
43	34.3	25.9	103	82.3	62.0	163	130.2	98.1	223	178.1	134.2	283	226.0	170.3
44	35.1	26.5	104	83.1	62.6	164	131.0	98.7	224	178.9	134.8	284	226.8	170.9
45	35.9	27.1	105	83.9	63.2	165	131.8	99.3	225	179.7	135.4	285	227.6	171.5
46	36.7	27.7	106	84.7	63.8	166	132.6	99.9	226	180.5	136.0	286	228.4	172.1
47	37.5	28.3	107	85.5	64.4	167	133.4	100.5	227	181.3	136.6	287	229.2	172.7
48	38.3	28.9	108	86.3	65.0	168	134.2	101.1	228	182.1	137.2	288	230.0	173.3
49	39.1	29.5	109	87.1	65.6	169	135.0	101.7	229	182.9	137.8	289	230.8	173.9
50	39.9	30.1	110	87.8	66.2	170	135.8	102.3	230	183.7	138.4	290	231.6	174.5
51	40.7	30.7	111	88.6	66.8	171	136.6	102.9	231	184.5	139.0	291	232.4	175.1
52	41.5	31.3	112	89.4	67.4	172	137.4	103.5	232	185.3	139.6	292	233.2	175.7
53	42.3	31.9	113	90.2	68.0	173	138.2	104.1	233	186.1	140.2	293	234.0	176.3
54	43.1	32.5	114	91.0	68.6	174	139.0	104.7	234	186.9	140.8	294	234.8	176.9
55	43.9	33.1	115	91.8	69.2	175	139.8	105.3	235	187.7	141.4	295	235.6	177.5
56	44.7	33.7	116	92.6	69.8	176	140.6	105.9	236	188.5	142.0	296	236.4	178.1
57	45.5	34.3	117	93.4	70.4	177	141.4	106.5	237	189.3	142.6	297	237.2	178.7
58	46.3	34.9	118	94.2	71.0	178	142.2	107.1	238	190.1	143.2	298	238.0	179.3
59	47.1	35.5	119	95.0	71.6	179	143.0	107.7	239	190.9	143.8	299	238.8	179.9
60	47.9	36.1	120	95.8	72.2	180	143.8	108.3	240	191.7	144.4	300	239.6	180.5
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

TABLE II.

Difference of Latitude and Departure for 38°.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.8	00.6	61	48.1	37.6	121	95.3	74.5	181	142.6	111.4	241	189.9	148.4
2	01.6	01.2	62	48.9	38.2	122	96.1	75.1	182	143.4	112.1	242	190.7	149.0
3	02.4	01.8	63	49.6	38.8	123	96.9	75.7	183	144.2	112.7	243	191.5	149.6
4	03.2	02.5	64	50.4	39.4	124	97.7	76.3	184	145.0	113.3	244	192.3	150.2
5	03.9	03.1	65	51.2	40.0	125	98.5	77.0	185	145.8	113.9	245	193.1	150.8
6	04.7	03.7	66	52.0	40.6	126	99.3	77.6	186	146.6	114.5	246	193.9	151.5
7	05.5	04.3	67	52.8	41.2	127	100.1	78.2	187	147.4	115.1	247	194.6	152.1
8	06.3	04.9	68	53.6	41.9	128	100.9	78.8	188	148.1	115.7	248	195.4	152.7
9	07.1	05.5	69	54.4	42.5	129	101.7	79.4	189	148.9	116.4	249	196.2	153.3
10	07.9	06.2	70	55.2	43.1	130	102.4	80.0	190	149.7	117.0	250	197.0	153.9
11	08.7	06.8	71	55.9	43.7	131	103.2	80.7	191	150.5	117.6	251	197.8	154.5
12	09.5	07.4	72	56.7	44.3	132	104.0	81.3	192	151.3	118.2	252	198.6	155.1
13	10.2	08.0	73	57.5	44.9	133	104.8	81.9	193	152.1	118.8	253	199.4	155.8
14	11.0	08.6	74	58.3	45.6	134	105.6	82.5	194	152.9	119.4	254	200.2	156.4
15	11.8	09.2	75	59.1	46.2	135	106.4	83.1	195	153.7	120.1	255	200.9	157.0
16	12.6	09.9	76	59.9	46.8	136	107.2	83.7	196	154.5	120.7	256	201.7	157.6
17	13.4	10.5	77	60.7	47.4	137	108.0	84.3	197	155.2	121.3	257	202.5	158.2
18	14.2	11.1	78	61.5	48.0	138	108.7	85.0	198	156.0	121.9	258	203.3	158.8
19	15.0	11.7	79	62.3	48.6	139	109.5	85.6	199	156.8	122.5	259	204.1	159.5
20	15.8	12.3	80	63.0	49.3	140	110.3	86.2	200	157.6	123.1	260	204.9	160.1
21	16.5	12.9	81	63.8	49.9	141	111.1	86.8	201	158.4	123.7	261	205.7	160.7
22	17.3	13.5	82	64.6	50.5	142	111.9	87.4	202	159.2	124.4	262	206.5	161.3
23	18.1	14.2	83	65.4	51.1	143	112.7	88.0	203	160.0	125.0	263	207.2	161.9
24	18.9	14.8	84	66.2	51.7	144	113.5	88.7	204	160.8	125.6	264	208.0	162.5
25	19.7	15.4	85	67.0	52.3	145	114.3	89.3	205	161.5	126.2	265	208.8	163.2
26	20.5	16.0	86	67.8	52.9	146	115.0	89.9	206	162.3	126.8	266	209.6	163.8
27	21.3	16.6	87	68.6	53.6	147	115.8	90.5	207	163.1	127.4	267	210.4	164.4
28	22.1	17.2	88	69.3	54.2	148	116.6	91.1	208	163.9	128.1	268	211.2	165.0
29	22.9	17.9	89	70.1	54.8	149	117.4	91.7	209	164.7	128.7	269	212.0	165.6
30	23.6	18.5	90	70.9	55.4	150	118.2	92.3	210	165.5	129.3	270	212.8	166.2
31	24.4	19.1	91	71.7	56.0	151	119.0	93.0	211	166.3	129.9	271	213.6	166.8
32	25.2	19.7	92	72.5	56.6	152	119.8	93.6	212	167.1	130.5	272	214.3	167.5
33	26.0	20.3	93	73.3	57.3	153	120.6	94.2	213	167.8	131.1	273	215.1	168.1
34	26.8	20.9	94	74.1	57.9	154	121.4	94.8	214	168.6	131.8	274	215.9	168.7
35	27.6	21.5	95	74.9	58.5	155	122.1	95.4	215	169.4	132.4	275	216.7	169.3
36	28.4	22.2	96	75.6	59.1	156	122.9	96.0	216	170.2	133.0	276	217.5	169.9
37	29.2	22.8	97	76.4	59.7	157	123.7	96.7	217	171.0	133.6	277	218.3	170.5
38	29.9	23.4	98	77.2	60.3	158	124.5	97.3	218	171.8	134.2	278	219.1	171.2
39	30.7	24.0	99	78.0	61.0	159	125.3	97.9	219	172.6	134.8	279	219.9	171.8
40	31.5	24.6	100	78.8	61.6	160	126.1	98.5	220	173.4	135.4	280	220.6	172.4
41	32.3	25.2	101	79.6	62.2	161	126.9	99.1	221	174.2	136.1	281	221.4	173.0
42	33.1	25.9	102	80.4	62.8	162	127.7	99.7	222	174.9	136.7	282	222.2	173.6
43	33.9	26.5	103	81.2	63.4	163	128.4	100.4	223	175.7	137.3	283	223.0	174.2
44	34.7	27.1	104	82.0	64.0	164	129.2	101.0	224	176.5	137.9	284	223.8	174.8
45	35.5	27.7	105	82.7	64.6	165	130.0	101.6	225	177.3	138.5	285	224.6	175.5
46	36.2	28.3	106	83.5	65.3	166	130.8	102.2	226	178.1	139.1	286	225.4	176.1
47	37.0	28.9	107	84.3	65.9	167	131.6	102.8	227	178.9	139.8	287	226.2	176.7
48	37.8	29.6	108	85.1	66.5	168	132.4	103.4	228	179.7	140.4	288	226.9	177.3
49	38.6	30.2	109	85.9	67.1	169	133.2	104.0	229	180.5	141.0	289	227.7	177.9
50	39.4	30.8	110	86.7	67.7	170	134.0	104.7	230	181.2	141.6	290	228.5	178.5
51	40.2	31.4	111	87.5	68.3	171	134.7	105.3	231	182.0	142.2	291	229.3	179.2
52	41.0	32.0	112	88.3	69.0	172	135.5	105.9	232	182.8	142.8	292	230.1	179.8
53	41.8	32.6	113	89.0	69.6	173	136.3	106.5	233	183.6	143.4	293	230.9	180.4
54	42.6	33.2	114	89.8	70.2	174	137.1	107.1	234	184.4	144.1	294	231.7	181.0
55	43.3	33.9	115	90.6	70.8	175	137.9	107.7	235	185.2	144.7	295	232.5	181.6
56	44.1	34.5	116	91.4	71.4	176	138.7	108.4	236	186.0	145.3	296	233.3	182.2
57	44.9	35.1	117	92.2	72.0	177	139.5	109.0	237	186.8	145.9	297	234.0	182.9
58	45.7	35.7	118	93.0	72.6	178	140.3	109.6	238	187.5	146.5	298	234.8	183.5
59	46.5	36.3	119	93.8	73.3	179	141.1	110.2	239	188.3	147.1	299	235.6	184.1
60	47.3	36.9	120	94.6	73.9	180	141.8	110.8	240	189.1	147.8	300	236.4	184.7
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

TABLE II.

Difference of Latitude and Departure for 39°.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.8	00.6	61	47.4	38.4	121	94.0	76.1	181	140.7	113.9	241	187.3	151..
2	01.6	01.3	62	48.2	39.0	122	94.8	76.8	182	141.4	114.5	242	188.1	152.3
3	02.3	01.9	63	49.0	39.6	123	95.6	77.4	183	142.2	115.2	243	188.8	152.9
4	03.1	02.5	64	49.7	40.3	124	96.4	78.0	184	143.0	115.8	244	189.6	153.6
5	03.9	03.1	65	50.5	40.9	125	97.1	78.7	185	143.8	116.4	245	190.4	154.2
6	04.7	03.8	66	51.3	41.5	126	97.9	79.3	186	144.5	117.1	246	191.2	154.8
7	05.4	04.4	67	52.1	42.2	127	98.7	79.9	187	145.3	117.7	247	192.0	155.4
8	06.2	05.0	68	52.8	42.8	128	99.5	80.6	188	146.1	118.3	248	192.7	156.1
9	07.0	05.7	69	53.6	43.4	129	100.3	81.2	189	146.9	118.9	249	193.5	156.7
10	07.8	06.3	70	54.4	44.1	130	101.0	81.8	190	147.7	119.6	250	194.3	157.3
11	08.5	06.9	71	55.2	44.7	131	101.8	82.4	191	148.4	120.2	251	195.1	158.0
12	09.3	07.6	72	56.0	45.3	132	102.6	83.1	192	149.2	120.8	252	195.8	158.6
13	10.1	08.2	73	56.7	45.9	133	103.4	83.7	193	150.0	121.5	253	196.6	159.2
14	10.9	08.8	74	57.5	46.6	134	104.1	84.3	194	150.8	122.1	254	197.4	159.8
15	11.7	09.4	75	58.3	47.2	135	104.9	85.0	195	151.5	122.7	255	198.2	160.5
16	12.4	10.1	76	59.1	47.8	136	105.7	85.6	196	152.3	123.3	256	198.9	161.1
17	13.2	10.7	77	59.8	48.5	137	106.5	86.2	197	153.1	124.0	257	199.7	161.7
18	14.0	11.3	78	60.6	49.1	138	107.2	86.8	198	153.9	124.6	258	200.5	162.4
19	14.8	12.0	79	61.4	49.7	139	108.0	87.5	199	154.7	125.2	259	201.3	163.0
20	15.5	12.6	80	62.2	50.3	140	108.8	88.1	200	155.4	125.9	260	202.1	163.6
21	16.3	13.2	81	62.9	51.0	141	109.6	88.7	201	156.2	126.5	261	202.8	164.3
22	17.1	13.8	82	63.7	51.6	142	110.4	89.4	202	157.0	127.1	262	203.6	164.9
23	17.9	14.5	83	64.5	52.2	143	111.1	90.0	203	157.8	127.8	263	204.4	165.5
24	18.7	15.1	84	65.3	52.9	144	111.9	90.6	204	158.5	128.4	264	205.2	166.1
25	19.4	15.7	85	66.1	53.5	145	112.7	91.3	205	159.3	129.0	265	205.9	166.8
26	20.2	16.4	86	66.8	54.1	146	113.5	91.9	206	160.1	129.6	266	206.7	167.4
27	21.0	17.0	87	67.6	54.8	147	114.2	92.5	207	160.9	130.3	267	207.5	168.0
28	21.8	17.6	88	68.4	55.4	148	115.0	93.1	208	161.6	130.9	268	208.3	168.7
29	22.5	18.3	89	69.2	56.0	149	115.8	93.8	209	162.4	131.5	269	209.1	169.3
30	23.3	18.9	90	69.9	56.6	150	116.6	94.4	210	163.2	132.2	270	209.8	169.9
31	24.1	19.5	91	70.7	57.3	151	117.3	95.0	211	164.0	132.8	271	210.6	170.5
32	24.9	20.1	92	71.5	57.9	152	118.1	95.7	212	164.8	133.4	272	211.4	171.2
33	25.6	20.8	93	72.3	58.5	153	118.9	96.3	213	165.5	134.0	273	212.2	171.8
34	26.4	21.4	94	73.1	59.2	154	119.7	96.9	214	166.3	134.7	274	212.9	172.4
35	27.2	22.0	95	73.8	59.8	155	120.5	97.5	215	167.1	135.3	275	213.7	173.1
36	28.0	22.7	96	74.6	60.4	156	121.2	98.2	216	167.9	135.9	276	214.5	173.7
37	28.8	23.3	97	75.4	61.0	157	122.0	98.8	217	168.6	136.6	277	215.3	174.3
38	29.5	23.9	98	76.2	61.7	158	122.8	99.4	218	169.4	137.2	278	216.0	175.0
39	30.3	24.5	99	76.9	62.3	159	123.6	100.1	219	170.2	137.8	279	216.8	175.6
40	31.1	25.2	100	77.7	62.9	160	124.3	100.7	220	171.0	138.5	280	217.6	176.2
41	31.9	25.8	101	78.5	63.6	161	125.1	101.3	221	171.7	139.1	281	218.4	176.8
42	32.6	26.4	102	79.3	64.2	162	125.9	101.9	222	172.5	139.7	282	219.2	177.5
43	33.4	27.1	103	80.0	64.8	163	126.7	102.6	223	173.3	140.3	283	219.9	178.1
44	34.1	27.7	104	80.8	65.4	164	127.5	103.2	224	174.1	141.0	284	220.7	178.7
45	35.0	28.3	105	81.6	66.1	165	128.2	103.8	225	174.9	141.6	285	221.5	179.4
46	35.7	28.9	106	82.4	66.7	166	129.0	104.5	226	175.6	142.2	286	222.3	180.0
47	36.5	29.6	107	83.2	67.3	167	129.8	105.1	227	176.4	142.9	287	223.0	180.6
48	37.3	30.2	108	83.9	68.0	168	130.6	105.7	228	177.2	143.5	288	223.8	181.2
49	38.1	30.8	109	84.7	68.6	169	131.3	106.4	229	178.0	144.1	289	224.6	181.9
50	38.9	31.5	110	85.5	69.2	170	132.1	107.0	230	178.7	144.7	290	225.4	182.5
51	39.6	32.1	111	86.3	69.9	171	132.9	107.6	231	179.5	145.4	291	226.1	183.1
52	40.4	32.7	112	87.0	70.5	172	133.7	108.2	232	180.3	146.0	292	226.9	183.8
53	41.2	33.4	113	87.8	71.1	173	134.4	108.9	233	181.1	146.6	293	227.7	184.4
54	42.0	34.0	114	88.6	71.7	174	135.2	109.5	234	181.9	147.3	294	228.5	185.0
55	42.7	34.6	115	89.4	72.4	175	136.0	110.1	235	182.6	147.9	295	229.3	185.6
56	43.5	35.2	116	90.1	73.0	176	136.8	110.8	236	183.4	148.5	296	230.0	186.3
57	44.3	35.9	117	90.9	73.6	177	137.6	111.4	237	184.2	149.1	297	230.8	186.9
58	45.1	36.5	118	91.7	74.3	178	138.3	112.0	238	185.0	149.8	298	231.6	187.5
59	45.9	37.1	119	92.5	74.9	179	139.1	112.6	239	185.7	150.4	299	232.4	188.2
60	46.6	37.8	120	93.3	75.5	180	139.9	113.3	240	186.5	151.0	300	233.1	188.8
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

TABLE II.

Difference of Latitude and Departure for 40°.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.8	00.6	61	46.7	39.2	121	92.7	77.8	181	138.7	116.3	241	184.6	154.9
2	01.5	01.3	62	47.5	39.9	122	93.5	78.4	182	139.4	117.0	242	185.4	155.6
3	02.3	01.9	63	48.3	40.5	123	94.2	79.1	183	140.2	117.6	243	186.1	156.2
4	03.1	02.6	64	49.0	41.1	124	95.0	79.7	184	141.0	118.3	244	186.9	156.8
5	03.8	03.2	65	49.8	41.8	125	95.8	80.3	185	141.7	118.9	245	187.7	157.5
6	04.6	03.9	66	50.6	42.4	126	96.5	81.0	186	142.5	119.6	246	188.4	158.1
7	05.4	04.5	67	51.3	43.1	127	97.3	81.6	187	143.3	120.2	247	189.2	158.8
8	06.1	05.1	68	52.1	43.7	128	98.1	82.3	188	144.0	120.8	248	190.0	159.4
9	06.9	05.8	69	52.9	44.4	129	98.8	82.9	189	144.8	121.5	249	190.7	160.1
10	07.7	06.4	70	53.6	45.0	130	99.6	83.6	190	145.5	122.1	250	191.5	160.7
11	08.4	07.1	71	54.4	45.6	131	100.4	84.2	191	146.3	122.8	251	192.3	161.3
12	09.2	07.7	72	55.2	46.3	132	101.1	84.8	192	147.1	123.4	252	193.0	162.0
13	10.0	08.4	73	55.9	46.9	133	101.9	85.5	193	147.8	124.1	253	193.8	162.6
14	10.7	09.0	74	56.7	47.6	134	102.6	86.1	194	148.6	124.7	254	194.6	163.3
15	11.5	09.6	75	57.5	48.2	135	103.4	86.8	195	149.4	125.3	255	195.3	163.9
16	12.3	10.3	76	58.2	48.9	136	104.2	87.4	196	150.1	126.0	256	196.1	164.6
17	13.0	10.9	77	59.0	49.5	137	104.9	88.1	197	150.9	126.6	257	196.9	165.2
18	13.8	11.6	78	59.8	50.1	138	105.7	88.7	198	151.7	127.3	258	197.6	165.8
19	14.6	12.2	79	60.5	50.8	139	106.5	89.3	199	152.4	127.9	259	198.4	166.5
20	15.3	12.9	80	61.3	51.4	140	107.2	90.0	200	153.2	128.6	260	199.2	167.1
21	16.1	13.5	81	62.0	52.1	141	108.0	90.6	201	154.0	129.2	261	199.9	167.8
22	16.9	14.1	82	62.8	52.7	142	108.8	91.3	202	154.7	129.8	262	200.7	168.4
23	17.6	14.8	83	63.6	53.4	143	109.5	91.9	203	155.5	130.5	263	201.5	169.1
24	18.4	15.4	84	64.3	54.0	144	110.3	92.6	204	156.3	131.1	264	202.2	169.7
25	19.2	16.1	85	65.1	54.6	145	111.1	93.2	205	157.0	131.8	265	203.0	170.3
26	19.9	16.7	86	65.9	55.3	146	111.8	93.8	206	157.8	132.4	266	203.8	171.0
27	20.7	17.4	87	66.6	55.9	147	112.6	94.5	207	158.6	133.1	267	204.5	171.6
28	21.4	18.0	88	67.4	56.6	148	113.4	95.1	208	159.3	133.7	268	205.3	172.3
29	22.2	18.6	89	68.2	57.2	149	114.1	95.8	209	160.1	134.3	269	206.1	172.9
30	23.0	19.3	90	68.9	57.9	150	114.9	96.4	210	160.9	135.0	270	206.8	173.6
31	23.7	19.9	91	69.7	58.5	151	115.7	97.1	211	161.6	135.6	271	207.6	174.2
32	24.5	20.6	92	70.5	59.1	152	116.4	97.7	212	162.4	136.3	272	208.4	174.8
33	25.3	21.2	93	71.2	59.8	153	117.2	98.3	213	163.2	136.9	273	209.1	175.5
34	26.0	21.9	94	72.0	60.4	154	118.0	99.0	214	163.9	137.6	274	209.9	176.1
35	26.8	22.5	95	72.8	61.1	155	118.7	99.6	215	164.7	138.2	275	210.7	176.8
36	27.6	23.1	96	73.5	61.7	156	119.5	100.3	216	165.5	138.8	276	211.4	177.4
37	28.3	23.8	97	74.3	62.4	157	120.3	100.9	217	166.2	139.5	277	212.2	178.1
38	29.1	24.4	98	75.1	63.0	158	121.0	101.6	218	167.0	140.1	278	213.0	178.7
39	29.9	25.1	99	75.8	63.6	159	121.8	102.2	219	167.8	140.8	279	213.7	179.3
40	30.6	25.7	100	76.6	64.3	160	122.6	102.8	220	168.5	141.4	280	214.5	180.0
41	31.4	26.4	101	77.4	64.9	161	123.3	103.5	221	169.3	142.1	281	215.3	180.6
42	32.2	27.0	102	78.1	65.6	162	124.1	104.1	222	170.1	142.7	282	216.0	181.3
43	32.9	27.6	103	78.9	66.2	163	124.9	104.8	223	170.8	143.3	283	216.8	181.9
44	33.7	28.3	104	79.7	66.8	164	125.6	105.4	224	171.6	144.0	284	217.6	182.6
45	34.5	28.9	105	80.4	67.5	165	126.4	106.1	225	172.4	144.6	285	218.3	183.2
46	35.2	29.6	106	81.2	68.1	166	127.2	106.7	226	173.1	145.3	286	219.1	183.8
47	36.0	30.2	107	82.0	68.8	167	127.9	107.3	227	173.9	145.9	287	219.9	184.5
48	36.8	30.9	108	82.7	69.4	168	128.7	108.0	228	174.7	146.6	288	220.6	185.1
49	37.5	31.5	109	83.5	70.1	169	129.5	108.6	229	175.4	147.2	289	221.4	185.8
50	38.3	32.1	110	84.3	70.7	170	130.2	109.3	230	176.2	147.8	290	222.2	186.4
51	39.1	32.8	111	85.0	71.3	171	131.0	109.9	231	177.0	148.5	291	222.9	187.1
52	39.8	33.4	112	85.8	72.0	172	131.8	110.6	232	177.7	149.1	292	223.7	187.7
53	40.6	34.1	113	86.6	72.6	173	132.5	111.2	233	178.5	149.8	293	224.5	188.3
54	41.4	34.7	114	87.3	73.3	174	133.3	111.8	234	179.3	150.4	294	225.2	189.0
55	42.1	35.4	115	88.1	73.9	175	134.1	112.5	235	180.0	151.1	295	226.0	189.6
56	42.9	36.0	116	88.9	74.6	176	134.8	113.1	236	180.8	151.7	296	226.7	190.3
57	43.7	36.6	117	89.6	75.2	177	135.6	113.8	237	181.6	152.3	297	227.5	190.9
58	44.4	37.3	118	90.4	75.8	178	136.4	114.4	238	182.3	153.0	298	228.3	191.6
59	45.2	37.9	119	91.2	76.5	179	137.1	115.1	239	183.1	153.6	299	229.0	192.2
60	46.0	38.6	120	91.9	77.1	180	137.9	115.7	240	183.9	154.3	300	229.8	192.8
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Difference of Latitude and Departure for 41°.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.8	00.7	61	46.0	40.0	121	91.3	79.4	181	136.6	118.7	241	181.9	158.1
2	01.5	01.3	62	46.8	40.7	122	92.1	80.0	182	137.4	119.4	242	182.6	158.8
3	02.3	02.0	63	47.5	41.3	123	92.8	80.7	183	138.1	120.1	243	183.4	159.4
4	03.0	02.6	64	48.3	42.0	124	93.6	81.4	184	138.9	120.7	244	184.1	160.1
5	03.8	03.3	65	49.1	42.6	125	94.3	82.0	185	139.6	121.4	245	184.9	160.7
6	04.5	03.9	66	49.8	43.3	126	95.1	82.7	186	140.4	122.0	246	185.7	161.4
7	05.3	04.6	67	50.6	44.0	127	95.8	83.3	187	141.1	122.7	247	186.4	162.0
8	06.0	05.2	68	51.3	44.6	128	96.6	84.0	188	141.9	123.3	248	187.2	162.7
9	06.8	05.9	69	52.1	45.3	129	97.4	84.6	189	142.6	124.0	249	187.9	163.4
10	07.5	06.6	70	52.8	45.9	130	98.1	85.3	190	143.4	124.7	250	188.7	164.0
11	08.3	07.2	71	53.6	46.6	131	98.9	85.9	191	144.1	125.3	251	189.4	164.7
12	09.1	07.9	72	54.3	47.2	132	99.6	86.6	192	144.9	126.0	252	190.2	165.3
13	09.8	08.5	73	55.1	47.9	133	100.4	87.3	193	145.7	126.6	253	190.9	166.0
14	10.6	09.2	74	55.8	48.5	134	101.1	87.9	194	146.4	127.3	254	191.7	166.6
15	11.3	09.8	75	56.6	49.2	135	101.9	88.6	195	147.2	127.9	255	192.5	167.3
16	12.1	10.5	76	57.4	49.9	136	102.6	89.2	196	147.9	128.6	256	193.2	168.0
17	12.8	11.2	77	58.1	50.5	137	103.4	89.9	197	148.7	129.2	257	194.0	168.6
18	13.6	11.8	78	58.9	51.2	138	104.1	90.5	198	149.4	129.9	258	194.7	169.3
19	14.3	12.5	79	59.6	51.8	139	104.9	91.2	199	150.2	130.6	259	195.5	169.9
20	15.1	13.1	80	60.4	52.5	140	105.7	91.8	200	150.9	131.2	260	196.2	170.6
21	15.8	13.8	81	61.1	53.1	141	106.4	92.5	201	151.7	131.9	261	197.0	171.2
22	16.6	14.4	82	61.9	53.8	142	107.2	93.2	202	152.5	132.5	262	197.7	171.9
23	17.4	15.1	83	62.6	54.5	143	107.9	93.8	203	153.2	133.2	263	198.5	172.5
24	18.1	15.7	84	63.4	55.1	144	108.7	94.5	204	154.0	133.8	264	199.2	173.2
25	18.9	16.4	85	64.2	55.8	145	109.4	95.1	205	154.7	134.5	265	200.0	173.9
26	19.6	17.1	86	64.9	56.4	146	110.2	95.8	206	155.5	135.1	266	200.8	174.5
27	20.4	17.7	87	65.7	57.1	147	110.9	96.4	207	156.2	135.8	267	201.5	175.2
28	21.1	18.4	88	66.4	57.7	148	111.7	97.1	208	157.0	136.5	268	202.3	175.8
29	21.9	19.0	89	67.2	58.4	149	112.5	97.8	209	157.7	137.1	269	203.0	176.5
30	22.6	19.7	90	67.9	59.0	150	113.2	98.4	210	158.5	137.8	270	203.8	177.1
31	23.4	20.3	91	68.7	59.7	151	114.0	99.1	211	159.2	138.4	271	204.5	177.8
32	24.2	21.0	92	69.4	60.4	152	114.7	99.7	212	160.0	139.1	272	205.3	178.4
33	24.9	21.6	93	70.2	61.0	153	115.5	100.4	213	160.8	139.7	273	206.0	179.1
34	25.7	22.3	94	70.9	61.7	154	116.2	101.0	214	161.5	140.4	274	206.8	179.8
35	26.4	23.0	95	71.7	62.3	155	117.0	101.7	215	162.3	141.1	275	207.5	180.4
36	27.2	23.6	96	72.5	63.0	156	117.7	102.3	216	163.0	141.7	276	208.3	181.1
37	27.9	24.3	97	73.2	63.6	157	118.5	103.0	217	163.8	142.4	277	209.1	181.7
38	28.7	24.9	98	74.0	64.3	158	119.2	103.7	218	164.5	143.0	278	209.8	182.4
39	29.4	25.6	99	74.7	64.9	159	120.0	104.3	219	165.3	143.7	279	210.6	183.0
40	30.2	26.2	100	75.5	65.6	160	120.8	105.0	220	166.0	144.3	280	211.3	183.7
41	30.9	26.9	101	76.2	66.3	161	121.5	105.6	221	166.8	145.0	281	212.1	184.4
42	31.7	27.6	102	77.0	66.9	162	122.3	106.3	222	167.5	145.6	282	212.8	185.0
43	32.5	28.2	103	77.7	67.6	163	123.0	106.9	223	168.3	146.3	283	213.6	185.7
44	33.2	28.9	104	78.5	68.2	164	123.8	107.6	224	169.1	147.0	284	214.3	186.3
45	34.0	29.5	105	79.2	68.9	165	124.5	108.2	225	169.8	147.6	285	215.1	187.0
46	34.7	30.2	106	80.0	69.5	166	125.3	108.9	226	170.6	148.3	286	215.8	187.6
47	35.5	30.8	107	80.8	70.2	167	126.0	109.6	227	171.3	148.9	287	216.6	188.3
48	36.2	31.5	108	81.5	70.9	168	126.8	110.2	228	172.1	149.6	288	217.4	188.9
49	37.0	32.1	109	82.3	71.5	169	127.5	110.9	229	172.8	150.2	289	218.1	189.6
50	37.7	32.8	110	83.0	72.2	170	128.3	111.5	230	173.6	150.9	290	218.9	190.3
51	38.5	33.5	111	83.8	72.8	171	129.1	112.2	231	174.3	151.5	291	219.6	190.9
52	39.2	34.1	112	84.5	73.5	172	129.8	112.8	232	175.1	152.2	292	220.4	191.6
53	40.0	34.8	113	85.3	74.1	173	130.6	113.5	233	175.8	152.9	293	221.1	192.2
54	40.8	35.4	114	86.0	74.8	174	131.3	114.2	234	176.6	153.5	294	221.9	192.9
55	41.5	36.1	115	86.8	75.4	175	132.1	114.8	235	177.4	154.2	295	222.6	193.5
56	42.3	36.7	116	87.5	76.1	176	132.8	115.5	236	178.1	154.8	296	223.4	194.2
57	43.0	37.4	117	88.3	76.8	177	133.6	116.1	237	178.9	155.5	297	224.1	194.8
58	43.8	38.1	118	89.1	77.4	178	134.3	116.8	238	179.6	156.1	298	224.9	195.5
59	44.5	38.7	119	89.8	78.1	179	135.1	117.4	239	180.4	156.8	299	225.7	196.2
60	45.3	39.4	120	90.6	78.7	180	135.8	118.1	240	181.1	157.5	300	226.4	196.8
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

TABLE II.

Difference of Latitude and Departure for 42°.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.7	00.7	61	45.3	40.8	121	89.9	81.0	181	134.5	121.1	241	179.1	161.3
2	01.5	01.3	62	46.1	41.5	122	90.7	81.6	182	135.3	121.8	242	179.8	161.9
3	02.2	02.0	63	46.8	42.2	123	91.4	82.3	183	136.0	122.5	243	180.6	162.6
4	03.0	02.7	64	47.6	42.8	124	92.1	83.0	184	136.7	123.1	244	181.3	163.3
5	03.7	03.3	65	48.3	43.5	125	92.9	83.6	185	137.5	123.8	245	182.1	163.9
6	04.5	04.0	66	49.0	44.2	126	93.6	84.3	186	138.2	124.5	246	182.8	164.6
7	05.2	04.7	67	49.8	44.8	127	94.4	85.0	187	139.0	125.1	247	183.6	165.3
8	05.9	05.4	68	50.5	45.5	128	95.1	85.6	188	139.7	125.8	248	184.3	165.9
9	06.7	06.0	69	51.3	46.2	129	95.9	86.3	189	140.5	126.5	249	185.0	166.6
10	07.4	06.7	70	52.0	46.8	130	96.6	87.0	190	141.2	127.1	250	185.8	167.3
11	08.2	07.4	71	52.8	47.5	131	97.4	87.7	191	141.9	127.8	251	186.5	168.0
12	08.9	08.0	72	53.5	48.2	132	98.1	88.3	192	142.7	128.5	252	187.3	168.6
13	09.7	08.7	73	54.2	48.8	133	98.8	89.0	193	143.4	129.1	253	188.0	169.3
14	10.4	09.4	74	55.0	49.5	134	99.6	89.7	194	144.2	129.8	254	188.8	170.0
15	11.1	10.0	75	55.7	50.2	135	100.3	90.3	195	144.9	130.5	255	189.5	170.6
16	11.9	10.7	76	56.5	50.9	136	101.1	91.0	196	145.7	131.1	256	190.2	171.3
17	12.6	11.4	77	57.2	51.5	137	101.8	91.7	197	146.4	131.8	257	191.0	172.0
18	13.4	12.0	78	58.0	52.2	138	102.6	92.3	198	147.1	132.5	258	191.7	172.6
19	14.1	12.7	79	58.7	52.9	139	103.3	93.0	199	147.9	133.2	259	192.5	173.3
20	14.9	13.4	80	59.5	53.5	140	104.0	93.7	200	148.6	133.8	260	193.2	174.0
21	15.6	14.1	81	60.2	54.2	141	104.8	94.3	201	149.4	134.5	261	194.0	174.6
22	16.3	14.7	82	60.9	54.9	142	105.5	95.0	202	150.1	135.2	262	194.7	175.3
23	17.1	15.4	83	61.7	55.5	143	106.3	95.7	203	150.9	135.8	263	195.4	176.0
24	17.8	16.1	84	62.4	56.2	144	107.0	96.4	204	151.6	136.5	264	196.2	176.7
25	18.6	16.7	85	63.2	56.9	145	107.8	97.0	205	152.3	137.2	265	196.9	177.3
26	19.3	17.4	86	63.9	57.5	146	108.5	97.7	206	153.1	137.8	266	197.7	178.0
27	20.1	18.1	87	64.7	58.2	147	109.2	98.4	207	153.8	138.5	267	198.4	178.7
28	20.8	18.7	88	65.4	58.9	148	110.0	99.0	208	154.6	139.2	268	199.2	179.3
29	21.6	19.4	89	66.1	59.6	149	110.7	99.7	209	155.3	139.8	269	199.9	180.0
30	22.3	20.1	90	66.9	60.2	150	111.5	100.4	210	156.1	140.5	270	200.6	180.7
31	23.0	20.7	91	67.6	60.9	151	112.2	101.0	211	156.8	141.2	271	201.4	181.3
32	23.8	21.4	92	68.4	61.6	152	113.0	101.7	212	157.5	141.9	272	202.1	182.0
33	24.5	22.1	93	69.1	62.2	153	113.7	102.4	213	158.3	142.5	273	202.9	182.7
34	25.3	22.8	94	69.9	62.9	154	114.4	103.0	214	159.0	143.2	274	203.6	183.3
35	26.0	23.4	95	70.6	63.6	155	115.2	103.7	215	159.8	143.9	275	204.4	184.0
36	26.8	24.1	96	71.3	64.2	156	115.9	104.4	216	160.5	144.5	276	205.1	184.7
37	27.5	24.8	97	72.1	64.9	157	116.7	105.1	217	161.3	145.2	277	205.9	185.3
38	28.2	25.4	98	72.8	65.6	158	117.4	105.7	218	162.0	145.9	278	206.6	186.0
39	29.0	26.1	99	73.6	66.2	159	118.2	106.4	219	162.7	146.5	279	207.3	186.7
40	29.7	26.8	100	74.3	66.9	160	118.9	107.1	220	163.5	147.2	280	208.1	187.4
41	30.5	27.4	101	75.1	67.6	161	119.6	107.7	221	164.2	147.9	281	208.8	188.0
42	31.2	28.1	102	75.8	68.3	162	120.4	108.4	222	165.0	148.5	282	209.6	188.7
43	32.0	28.8	103	76.5	68.9	163	121.1	109.1	223	165.7	149.2	283	210.3	189.4
44	32.7	29.4	104	77.3	69.6	164	121.9	109.7	224	166.5	149.9	284	211.1	190.0
45	33.4	30.1	105	78.0	70.3	165	122.6	110.4	225	167.2	150.6	285	211.8	190.7
46	34.2	30.8	106	78.8	70.9	166	123.4	111.1	226	168.0	151.2	286	212.5	191.4
47	34.9	31.4	107	79.5	71.6	167	124.1	111.7	227	168.7	151.9	287	213.3	192.0
48	35.7	32.1	108	80.3	72.3	168	124.8	112.4	228	169.4	152.6	288	214.0	192.7
49	36.4	32.8	109	81.0	72.9	169	125.6	113.1	229	170.2	153.2	289	214.8	193.4
50	37.2	33.5	110	81.7	73.6	170	126.3	113.8	230	170.9	153.9	290	215.5	194.0
51	37.9	34.1	111	82.5	74.3	171	127.1	114.4	231	171.7	154.6	291	216.3	194.7
52	38.6	34.8	112	83.2	74.9	172	127.8	115.1	232	172.4	155.2	292	217.0	195.4
53	39.4	35.5	113	84.0	75.6	173	128.6	115.8	233	173.2	155.9	293	217.7	196.1
54	40.1	36.1	114	84.7	76.3	174	129.3	116.4	234	173.9	156.6	294	218.5	196.7
55	40.9	36.8	115	85.5	77.0	175	130.1	117.1	235	174.6	157.2	295	219.2	197.4
56	41.6	37.5	116	86.2	77.6	176	130.8	117.8	236	175.4	157.9	296	220.0	198.1
57	42.4	38.1	117	86.9	78.3	177	131.5	118.4	237	176.1	158.6	297	220.7	198.7
58	43.1	38.8	118	87.7	79.0	178	132.3	119.1	238	176.9	159.3	298	221.5	199.4
59	43.8	39.5	119	88.4	79.6	179	133.0	119.8	239	177.6	159.9	299	222.2	200.1
60	44.6	40.1	120	89.2	80.3	180	133.8	120.4	240	178.4	160.6	300	222.9	200.7
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Difference of Latitude and Departure for 43°.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.7	00.7	61	44.6	41.6	121	88.5	82.5	181	132.4	123.4	241	176.3	164.4
2	01.5	01.4	62	45.3	42.3	122	89.2	83.2	182	133.1	124.1	242	177.0	165.0
3	02.2	02.0	63	46.1	43.0	123	90.0	83.9	183	133.8	124.8	243	177.7	165.7
4	02.9	02.7	64	46.8	43.6	124	90.7	84.6	184	134.6	125.5	244	178.5	166.4
5	03.7	03.4	65	47.5	44.3	125	91.4	85.2	185	135.3	126.2	245	179.2	167.1
6	04.4	04.1	66	48.3	45.0	126	92.2	85.9	186	136.0	126.9	246	179.9	167.8
7	05.1	04.8	67	49.0	45.7	127	92.9	86.6	187	136.8	127.5	247	180.6	168.5
8	05.9	05.5	68	49.7	46.4	128	93.6	87.3	188	137.5	128.2	248	181.4	169.1
9	06.6	06.1	69	50.5	47.1	129	94.3	88.0	189	138.2	128.9	249	182.1	169.8
10	07.3	06.8	70	51.2	47.7	130	95.1	88.7	190	139.0	129.6	250	182.8	170.5
11	08.0	07.5	71	51.9	48.4	131	95.8	89.3	191	139.7	130.3	251	183.6	171.2
12	08.8	08.2	72	52.7	49.1	132	96.5	90.0	192	140.4	130.9	252	184.3	171.9
13	09.5	08.9	73	53.4	49.8	133	97.3	90.7	193	141.2	131.6	253	185.0	172.5
14	10.2	09.5	74	54.1	50.5	134	98.0	91.4	194	141.9	132.3	254	185.8	173.2
15	11.0	10.2	75	54.9	51.1	135	98.7	92.1	195	142.6	133.0	255	186.5	173.9
16	11.7	10.9	76	55.6	51.8	136	99.5	92.8	196	143.3	133.7	256	187.2	174.6
17	12.4	11.6	77	56.3	52.5	137	100.2	93.4	197	144.1	134.4	257	188.0	175.3
18	13.2	12.3	78	57.0	53.2	138	100.9	94.1	198	144.8	135.0	258	188.7	176.0
19	13.9	13.0	79	57.8	53.9	139	101.7	94.8	199	145.5	135.7	259	189.4	176.6
20	14.6	13.6	80	58.5	54.6	140	102.4	95.5	200	146.3	136.4	260	190.2	177.3
21	15.4	14.3	81	59.2	55.2	141	103.1	96.2	201	147.0	137.1	261	190.9	178.0
22	16.1	15.0	82	60.0	55.9	142	103.9	96.8	202	147.7	137.8	262	191.6	178.7
23	16.8	15.7	83	60.7	56.6	143	104.6	97.5	203	148.5	138.4	263	192.3	179.4
24	17.6	16.4	84	61.4	57.3	144	105.3	98.2	204	149.2	139.1	264	193.1	180.0
25	18.3	17.0	85	62.2	58.0	145	106.0	98.9	205	149.9	139.8	265	193.8	180.7
26	19.0	17.7	86	62.9	58.7	146	106.8	99.6	206	150.7	140.5	266	194.5	181.4
27	19.7	18.4	87	63.6	59.3	147	107.5	100.3	207	151.4	141.2	267	195.3	182.1
28	20.5	19.1	88	64.4	60.0	148	108.2	100.9	208	152.1	141.9	268	196.0	182.8
29	21.2	19.8	89	65.1	60.7	149	109.0	101.6	209	152.9	142.5	269	196.7	183.5
30	21.9	20.5	90	65.8	61.4	150	109.7	102.3	210	153.6	143.2	270	197.5	184.1
31	22.7	21.1	91	66.6	62.1	151	110.4	103.0	211	154.3	143.9	271	198.2	184.8
32	23.4	21.8	92	67.3	62.7	152	111.2	103.7	212	155.0	144.6	272	198.9	185.5
33	24.1	22.5	93	68.0	63.4	153	111.9	104.3	213	155.8	145.3	273	199.7	186.2
34	24.9	23.2	94	68.7	64.1	154	112.6	105.0	214	156.5	145.9	274	200.4	186.9
35	25.6	23.9	95	69.5	64.8	155	113.4	105.7	215	157.2	146.6	275	201.1	187.5
36	26.3	24.6	96	70.2	65.5	156	114.1	106.4	216	158.0	147.3	276	201.9	188.2
37	27.1	25.2	97	70.9	66.2	157	114.8	107.1	217	158.7	148.0	277	202.6	188.9
38	27.8	25.9	98	71.7	66.8	158	115.6	107.8	218	159.4	148.7	278	203.3	189.6
39	28.5	26.6	99	72.4	67.5	159	116.3	108.4	219	160.2	149.4	279	204.0	190.3
40	29.3	27.3	100	73.1	68.2	160	117.0	109.1	220	160.9	150.0	280	204.8	191.0
41	30.0	28.0	101	73.9	68.9	161	117.7	109.8	221	161.6	150.7	281	205.5	191.6
42	30.7	28.6	102	74.6	69.6	162	118.5	110.5	222	162.4	151.4	282	206.2	192.3
43	31.4	29.3	103	75.3	70.2	163	119.2	111.2	223	163.1	152.1	283	207.0	193.0
44	32.2	30.0	104	76.1	70.9	164	119.9	111.8	224	163.8	152.8	284	207.7	193.7
45	32.9	30.7	105	76.8	71.6	165	120.7	112.5	225	164.6	153.4	285	208.4	194.4
46	33.6	31.4	106	77.5	72.3	166	121.4	113.2	226	165.3	154.1	286	209.2	195.1
47	34.4	32.1	107	78.3	73.0	167	122.1	113.9	227	166.0	154.8	287	209.9	195.7
48	35.1	32.7	108	79.0	73.7	168	122.9	114.6	228	166.7	155.5	288	210.6	196.4
49	35.8	33.4	109	79.7	74.3	169	123.6	115.3	229	167.5	156.2	289	211.4	197.1
50	36.6	34.1	110	80.4	75.0	170	124.3	115.9	230	168.2	156.9	290	212.1	197.8
51	37.3	34.8	111	81.2	75.7	171	125.1	116.6	231	168.9	157.5	291	212.8	198.5
52	38.0	35.5	112	81.9	76.4	172	125.8	117.3	232	169.7	158.2	292	213.6	199.1
53	38.8	36.1	113	82.6	77.1	173	126.5	118.0	233	170.4	158.9	293	214.3	199.8
54	39.5	36.8	114	83.4	77.7	174	127.3	118.7	234	171.1	159.6	294	215.0	200.5
55	40.2	37.5	115	84.1	78.4	175	128.0	119.3	235	171.9	160.3	295	215.7	201.2
56	41.0	38.2	116	84.8	79.1	176	128.7	120.0	236	172.6	161.0	296	216.5	201.9
57	41.7	38.9	117	85.6	79.8	177	129.4	120.7	237	173.3	161.6	297	217.2	202.6
58	42.4	39.6	118	86.3	80.5	178	130.2	121.4	238	174.1	162.3	298	217.9	203.2
59	43.1	40.2	119	87.0	81.2	179	130.9	122.1	239	174.8	163.0	299	218.7	203.9
60	43.9	40.9	120	87.8	81.8	180	131.6	122.8	240	175.5	163.7	300	219.4	204.6
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

Difference of Latitude and Departure for 44°.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.7	00.7	61	43.9	42.4	121	87.0	84.1	181	130.2	125.7	241	173.4	167.4
2	01.4	01.4	62	44.6	43.1	122	87.8	84.7	182	130.9	126.4	242	174.1	168.1
3	02.2	02.1	63	45.3	43.8	123	88.5	85.4	183	131.6	127.1	243	174.8	168.8
4	02.9	02.8	64	46.0	44.5	124	89.2	86.1	184	132.4	127.8	244	175.5	169.5
5	03.6	03.5	65	46.8	45.2	125	89.9	86.8	185	133.1	128.5	245	176.2	170.2
6	04.3	04.2	66	47.5	45.8	126	90.6	87.5	186	133.8	129.2	246	177.0	170.9
7	05.0	04.9	67	48.2	46.5	127	91.4	88.2	187	134.5	129.9	247	177.7	171.6
8	05.8	05.6	68	48.9	47.2	128	92.1	88.9	188	135.2	130.6	248	178.4	172.3
9	06.5	06.3	69	49.6	47.9	129	92.8	89.6	189	136.0	131.3	249	179.1	173.0
10	07.2	06.9	70	50.4	48.6	130	93.5	90.3	190	136.7	132.0	250	179.8	173.7
11	07.9	07.6	71	51.1	49.3	131	94.2	91.0	191	137.4	132.7	251	180.6	174.4
12	08.6	08.3	72	51.8	50.0	132	95.0	91.7	192	138.1	133.4	252	181.3	175.1
13	09.4	09.0	73	52.5	50.7	133	95.7	92.4	193	138.8	134.1	253	182.0	175.7
14	10.1	09.7	74	53.2	51.4	134	96.4	93.1	194	139.6	134.8	254	182.7	176.4
15	10.8	10.4	75	54.0	52.1	135	97.1	93.8	195	140.3	135.5	255	183.4	177.1
16	11.5	11.1	76	54.7	52.8	136	97.8	94.5	196	141.0	136.2	256	184.2	177.8
17	12.2	11.8	77	55.4	53.5	137	98.5	95.2	197	141.7	136.8	257	184.9	178.5
18	12.9	12.5	78	56.1	54.2	138	99.3	95.9	198	142.4	137.5	258	185.6	179.2
19	13.7	13.2	79	56.8	54.9	139	100.0	96.6	199	143.1	138.2	259	186.3	179.9
20	14.4	13.9	80	57.5	55.6	140	100.7	97.3	200	143.9	138.9	260	187.0	180.6
21	15.1	14.6	81	58.3	56.3	141	101.4	97.9	201	144.6	139.6	261	187.7	181.3
22	15.8	15.3	82	59.0	57.0	142	102.1	98.6	202	145.3	140.3	262	188.5	182.0
23	16.5	16.0	83	59.7	57.7	143	102.9	99.3	203	146.0	141.0	263	189.2	182.7
24	17.3	16.7	84	60.4	58.4	144	103.6	100.0	204	146.7	141.7	264	189.9	183.4
25	18.0	17.4	85	61.1	59.0	145	104.3	100.7	205	147.5	142.4	265	190.6	184.1
26	18.7	18.1	86	61.9	59.7	146	105.0	101.4	206	148.2	143.1	266	191.3	184.8
27	19.4	18.8	87	62.6	60.4	147	105.7	102.1	207	148.9	143.8	267	192.1	185.5
28	20.1	19.5	88	63.3	61.1	148	106.5	102.8	208	149.6	144.5	268	192.8	186.2
29	20.9	20.1	89	64.0	61.8	149	107.2	103.5	209	150.3	145.2	269	193.5	186.9
30	21.6	20.8	90	64.7	62.5	150	107.9	104.2	210	151.1	145.9	270	194.2	187.6
31	22.3	21.5	91	65.5	63.2	151	108.6	104.9	211	151.8	146.6	271	194.9	188.3
32	23.0	22.2	92	66.2	63.9	152	109.3	105.6	212	152.5	147.3	272	195.7	188.9
33	23.7	22.9	93	66.9	64.6	153	110.1	106.3	213	153.2	148.0	273	196.4	189.6
34	24.5	23.6	94	67.6	65.3	154	110.8	107.0	214	153.9	148.7	274	197.1	190.3
35	25.2	24.3	95	68.3	66.0	155	111.5	107.7	215	154.7	149.4	275	197.8	191.0
36	25.9	25.0	96	69.1	66.7	156	112.2	108.4	216	155.4	150.0	276	198.5	191.7
37	26.6	25.7	97	69.8	67.4	157	112.9	109.1	217	156.1	150.7	277	199.3	192.4
38	27.3	26.4	98	70.5	68.1	158	113.7	109.8	218	156.8	151.4	278	200.0	193.1
39	28.1	27.1	99	71.2	68.8	159	114.4	110.5	219	157.5	152.1	279	200.7	193.8
40	28.8	27.8	100	71.9	69.5	160	115.1	111.1	220	158.3	152.8	280	201.4	194.5
41	29.5	28.5	101	72.7	70.2	161	115.8	111.8	221	159.0	153.5	281	202.1	195.2
42	30.2	29.2	102	73.4	70.9	162	116.5	112.5	222	159.7	154.2	282	202.9	195.9
43	30.9	29.9	103	74.1	71.5	163	117.3	113.2	223	160.4	154.9	283	203.6	196.6
44	31.7	30.6	104	74.8	72.2	164	118.0	113.9	224	161.1	155.6	284	204.3	197.3
45	32.4	31.3	105	75.5	72.9	165	118.7	114.6	225	161.9	156.3	285	205.0	198.0
46	33.1	32.0	106	76.3	73.6	166	119.4	115.3	226	162.6	157.0	286	205.7	198.7
47	33.8	32.6	107	77.0	74.3	167	120.1	116.0	227	163.3	157.7	287	206.5	199.4
48	34.5	33.3	108	77.7	75.0	168	120.8	116.7	228	164.0	158.4	288	207.2	200.1
49	35.2	34.0	109	78.4	75.7	169	121.6	117.4	229	164.7	159.1	289	207.9	200.8
50	36.0	34.7	110	79.1	76.4	170	122.3	118.1	230	165.4	159.8	290	208.6	201.5
51	36.7	35.4	111	79.8	77.1	171	123.0	118.8	231	166.2	160.5	291	209.3	202.1
52	37.4	36.1	112	80.6	77.8	172	123.7	119.5	232	166.9	161.2	292	210.0	202.8
53	38.1	36.8	113	81.3	78.5	173	124.4	120.2	233	167.6	161.9	293	210.8	203.5
54	38.8	37.5	114	82.0	79.2	174	125.2	120.9	234	168.3	162.6	294	211.5	204.2
55	39.6	38.2	115	82.7	79.9	175	125.9	121.6	235	169.0	163.2	295	212.2	204.9
56	40.3	38.9	116	83.4	80.6	176	126.6	122.3	236	169.8	163.9	296	212.9	205.6
57	41.0	39.6	117	84.2	81.3	177	127.3	123.0	237	170.5	164.6	297	213.6	206.3
58	41.7	40.3	118	84.9	82.0	178	128.0	123.6	238	171.2	165.3	298	214.4	207.0
59	42.4	41.0	119	85.6	82.7	179	128.8	124.3	239	171.9	166.0	299	215.1	207.7
60	43.2	41.7	120	86.3	83.4	180	129.5	125.0	240	172.6	166.7	300	215.8	208.4
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist	Dep.	Lat.	Dist.	Dep.	Lat.

Difference of Latitude and Departure for 45°.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.7	00.7	61	43.1	43.1	121	85.6	85.6	181	128.0	128.0	241	170.4	170.4
2	01.4	01.4	62	43.8	43.8	122	86.3	86.3	182	128.7	128.7	242	171.1	171.1
3	02.1	02.1	63	44.5	44.5	123	87.0	87.0	183	129.4	129.4	243	171.8	171.8
4	02.8	02.8	64	45.3	45.3	124	87.7	87.7	184	130.1	130.1	244	172.5	172.5
5	03.5	03.5	65	46.0	46.0	125	88.4	88.4	185	130.8	130.8	245	173.2	173.2
6	04.2	04.2	66	46.7	46.7	126	89.1	89.1	186	131.5	131.5	246	173.9	173.9
7	04.9	04.9	67	47.4	47.4	127	89.8	89.8	187	132.2	132.2	247	174.7	174.7
8	05.7	05.7	68	48.1	48.1	128	90.5	90.5	188	132.9	132.9	248	175.4	175.4
9	06.4	06.4	69	48.8	48.8	129	91.2	91.2	189	133.6	133.6	249	176.1	176.1
10	07.1	07.1	70	49.5	49.5	130	91.9	91.9	190	134.4	134.4	250	176.8	176.8
11	07.8	07.8	71	50.2	50.2	131	92.6	92.6	191	135.1	135.1	251	177.5	177.5
12	08.5	08.5	72	50.9	50.9	132	93.3	93.3	192	135.8	135.8	252	178.2	178.2
13	09.2	09.2	73	51.6	51.6	133	94.0	94.0	193	136.5	136.5	253	178.9	178.9
14	09.9	09.9	74	52.3	52.3	134	94.8	94.8	194	137.2	137.2	254	179.6	179.6
15	10.6	10.6	75	53.0	53.0	135	95.5	95.5	195	137.9	137.9	255	180.3	180.3
16	11.3	11.3	76	53.7	53.7	136	96.2	96.2	196	138.6	138.6	256	181.0	181.0
17	12.0	12.0	77	54.4	54.4	137	96.9	96.9	197	139.3	139.3	257	181.7	181.7
18	12.7	12.7	78	55.2	55.2	138	97.6	97.6	198	140.0	140.0	258	182.4	182.4
19	13.4	13.4	79	55.9	55.9	139	98.3	98.3	199	140.7	140.7	259	183.1	183.1
20	14.1	14.1	80	56.6	56.6	140	99.0	99.0	200	141.4	141.4	260	183.8	183.8
21	14.8	14.8	81	57.3	57.3	141	99.7	99.7	201	142.1	142.1	261	184.6	184.6
22	15.6	15.6	82	58.0	58.0	142	100.4	100.4	202	142.8	142.8	262	185.3	185.3
23	16.3	16.3	83	58.7	58.7	143	101.1	101.1	203	143.5	143.5	263	186.0	186.0
24	17.0	17.0	84	59.4	59.4	144	101.8	101.8	204	144.2	144.2	264	186.7	186.7
25	17.7	17.7	85	60.1	60.1	145	102.5	102.5	205	145.0	145.0	265	187.4	187.4
26	18.4	18.4	86	60.8	60.8	146	103.2	103.2	206	145.7	145.7	266	188.1	188.1
27	19.1	19.1	87	61.5	61.5	147	103.9	103.9	207	146.4	146.4	267	188.8	188.8
28	19.8	19.8	88	62.2	62.2	148	104.7	104.7	208	147.1	147.1	268	189.5	189.5
29	20.5	20.5	89	62.9	62.9	149	105.4	105.4	209	147.8	147.8	269	190.2	190.2
30	21.2	21.2	90	63.6	63.6	150	106.1	106.1	210	148.5	148.5	270	190.9	190.9
31	21.9	21.9	91	64.3	64.3	151	106.8	106.8	211	149.2	149.2	271	191.6	191.6
32	22.6	22.6	92	65.1	65.1	152	107.5	107.5	212	149.9	149.9	272	192.3	192.3
33	23.3	23.3	93	65.8	65.8	153	108.2	108.2	213	150.6	150.6	273	193.0	193.0
34	24.0	24.0	94	66.5	66.5	154	108.9	108.9	214	151.3	151.3	274	193.7	193.7
35	24.7	24.7	95	67.2	67.2	155	109.6	109.6	215	152.0	152.0	275	194.5	194.5
36	25.5	25.5	96	67.9	67.9	156	110.3	110.3	216	152.7	152.7	276	195.2	195.2
37	26.2	26.2	97	68.6	68.6	157	111.0	111.0	217	153.4	153.4	277	195.9	195.9
38	26.9	26.9	98	69.3	69.3	158	111.7	111.7	218	154.1	154.1	278	196.6	196.6
39	27.6	27.6	99	70.0	70.0	159	112.4	112.4	219	154.9	154.9	279	197.3	197.3
40	28.3	28.3	100	70.7	70.7	160	113.1	113.1	220	155.6	155.6	280	198.0	198.0
41	29.0	29.0	101	71.4	71.4	161	113.8	113.8	221	156.3	156.3	281	198.7	198.7
42	29.7	29.7	102	72.1	72.1	162	114.6	114.6	222	157.0	157.0	282	199.4	199.4
43	30.4	30.4	103	72.8	72.8	163	115.3	115.3	223	157.7	157.7	283	200.1	200.1
44	31.1	31.1	104	73.5	73.5	164	116.0	116.0	224	158.4	158.4	284	200.8	200.8
45	31.8	31.8	105	74.2	74.2	165	116.7	116.7	225	159.1	159.1	285	201.5	201.5
46	32.5	32.5	106	75.0	75.0	166	117.4	117.4	226	159.8	159.8	286	202.2	202.2
47	33.2	33.2	107	75.7	75.7	167	118.1	118.1	227	160.5	160.5	287	202.9	202.9
48	33.9	33.9	108	76.4	76.4	168	118.8	118.8	228	161.2	161.2	288	203.6	203.6
49	34.6	34.6	109	77.1	77.1	169	119.5	119.5	229	161.9	161.9	289	204.4	204.4
50	35.4	35.4	110	77.8	77.8	170	120.2	120.2	230	162.6	162.6	290	205.1	205.1
51	36.1	36.1	111	78.5	78.5	171	120.9	120.9	231	163.3	163.3	291	205.8	205.8
52	36.8	36.8	112	79.2	79.2	172	121.6	121.6	232	164.0	164.0	292	206.5	206.5
53	37.5	37.5	113	79.9	79.9	173	122.3	122.3	233	164.8	164.8	293	207.2	207.2
54	38.2	38.2	114	80.6	80.6	174	123.0	123.0	234	165.5	165.5	294	207.9	207.9
55	38.9	38.9	115	81.3	81.3	175	123.7	123.7	235	166.2	166.2	295	208.6	208.6
56	39.6	39.6	116	82.0	82.0	176	124.5	124.5	236	166.9	166.9	296	209.3	209.3
57	40.3	40.3	117	82.7	82.7	177	125.2	125.2	237	167.6	167.6	297	210.0	210.0
58	41.0	41.0	118	83.4	83.4	178	125.9	125.9	238	168.3	168.3	298	210.7	210.7
59	41.7	41.7	119	84.1	84.1	179	126.6	126.6	239	169.0	169.0	299	211.4	211.4
60	42.4	42.4	120	84.9	84.9	180	127.3	127.3	240	169.7	169.7	300	212.1	212.1
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Ded.	Lat.

TABLE III.

MERIDIONAL PARTS.

′	0°	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°	13°	14°	15°
0	0	60	120	180	240	300	361	421	482	542	603	664	725	787	848	910
1	1	61	121	181	241	301	362	422	483	543	604	665	726	788	850	911
2	2	62	122	182	242	302	363	423	484	544	605	666	727	789	851	913
3	3	63	123	183	243	303	364	424	485	545	606	667	728	790	852	914
4	4	64	124	184	244	304	365	425	486	546	607	668	729	791	853	915
5	5	65	125	185	245	305	366	426	487	547	608	669	730	792	854	916
6	6	66	126	186	246	306	367	427	488	548	609	670	731	793	855	917
7	7	67	127	187	247	307	368	428	489	549	610	671	732	794	856	918
8	8	68	128	188	248	308	369	429	490	550	611	672	734	795	857	919
9	9	69	129	189	249	309	370	430	491	551	612	673	735	796	858	920
10	10	70	130	190	250	310	371	431	492	552	613	674	736	797	859	921
11	11	71	131	191	251	311	372	432	493	553	614	675	737	798	860	922
12	12	72	132	192	252	312	373	433	494	554	615	676	738	799	861	923
13	13	73	133	193	253	313	374	434	495	555	616	677	739	800	862	924
14	14	74	134	194	254	314	375	435	496	556	617	678	740	801	863	925
15	15	75	135	195	255	315	376	436	497	557	618	679	741	802	864	926
16	16	76	136	196	256	316	377	437	498	558	619	680	742	803	865	927
17	17	77	137	197	257	317	378	438	499	559	620	681	743	804	866	928
18	18	78	138	198	258	318	379	439	500	560	621	682	744	805	867	929
19	19	79	139	199	259	319	380	440	501	561	622	683	745	806	868	930
20	20	80	140	200	260	320	381	441	502	562	623	684	746	807	869	931
21	21	81	141	201	261	321	382	442	503	564	624	685	747	808	870	932
22	22	82	142	202	262	322	383	443	504	565	625	687	748	809	871	933
23	23	83	143	203	263	323	384	444	505	566	626	688	749	810	872	934
24	24	84	144	204	264	324	385	445	506	567	627	689	750	811	873	935
25	25	85	145	205	265	325	386	446	507	568	628	690	751	812	874	936
26	26	86	146	206	266	326	387	447	508	569	629	691	752	813	875	937
27	27	87	147	207	267	327	388	448	509	570	631	692	753	815	876	938
28	28	88	148	208	268	328	389	449	510	571	632	693	754	816	877	939
29	29	89	149	209	269	330	390	450	511	572	633	694	755	817	878	941
30	30	90	150	210	270	331	391	451	512	573	634	695	756	818	879	942
31	31	91	151	211	271	332	392	452	513	574	635	696	757	819	880	943
32	32	92	152	212	272	333	393	453	514	575	636	697	758	820	882	944
33	33	93	153	213	273	334	394	454	515	576	637	698	759	821	883	945
34	34	94	154	214	274	335	395	455	516	577	638	699	760	822	884	946
35	35	95	155	215	275	336	396	456	517	578	639	700	761	823	885	947
36	36	96	156	216	276	337	397	457	518	579	640	701	762	824	886	948
37	37	97	157	217	277	338	398	458	519	580	641	702	763	825	887	949
38	38	98	158	218	278	339	399	459	520	581	642	703	764	826	888	950
39	39	99	159	219	279	340	400	460	521	582	643	704	765	827	889	951
40	40	100	160	220	280	341	401	461	522	583	644	705	766	828	890	952
41	41	101	161	221	281	342	402	462	523	584	645	706	767	829	891	953
42	42	102	162	222	282	343	403	463	524	585	646	707	768	830	892	954
43	43	103	163	223	283	344	404	464	525	586	647	708	769	831	893	955
44	44	104	164	224	284	345	405	465	526	587	648	709	770	832	894	956
45	45	105	165	225	285	346	406	466	527	588	649	710	771	833	895	957
46	46	106	166	226	286	347	407	467	528	589	650	711	772	834	896	958
47	47	107	167	227	287	348	408	468	529	590	651	712	773	835	897	959
48	48	108	168	228	288	349	409	469	530	591	652	713	774	836	898	960
49	49	109	169	229	289	350	410	470	531	592	653	714	775	837	899	961
50	50	110	170	230	290	351	411	471	532	593	654	715	777	838	900	962
51	51	111	171	231	291	352	412	472	533	594	655	716	778	839	901	963
52	52	112	172	232	292	353	413	473	534	595	656	717	779	840	902	964
53	53	113	173	233	293	354	414	474	535	596	657	718	780	841	903	965
54	54	114	174	234	294	355	415	476	536	597	658	719	781	842	904	966
55	55	115	175	235	295	356	416	477	537	598	659	720	782	843	905	968
56	56	116	176	236	296	357	417	478	538	599	660	721	783	844	906	969
57	57	117	177	237	297	358	418	479	539	600	661	722	784	845	907	970
58	58	118	178	238	298	359	419	480	540	601	662	723	785	846	908	971
59	59	119	179	239	299	360	420	481	541	602	663	724	786	847	909	972

MERIDIONAL PARTS.

′	16°	17°	18°	19°	20°	21°	22°	23°	24°	25°	26°	27°	28°
0	973	1035	1098	1161	1225	1289	1354	1419	1484	1550	1616	1684	1751
1	974	1036	1099	1163	1226	1290	1355	1420	1485	1551	1618	1685	1752
2	975	1037	1100	1164	1227	1291	1356	1421	1486	1552	1619	1686	1753
3	976	1038	1101	1165	1228	1292	1357	1422	1487	1553	1620	1687	1755
4	977	1039	1102	1166	1229	1293	1358	1423	1488	1554	1621	1688	1756
5	978	1041	1103	1167	1230	1295	1359	1424	1490	1556	1622	1689	1757
6	979	1042	1105	1168	1232	1296	1360	1425	1491	1557	1623	1690	1758
7	980	1043	1106	1169	1233	1297	1361	1426	1492	1558	1624	1691	1759
8	981	1044	1107	1170	1234	1298	1362	1427	1493	1559	1625	1693	1760
9	982	1045	1108	1171	1235	1299	1363	1428	1494	1560	1626	1694	1761
10	983	1046	1109	1172	1236	1300	1364	1430	1495	1561	1628	1695	1762
11	984	1047	1110	1173	1237	1301	1366	1431	1496	1562	1629	1696	1764
12	985	1048	1111	1174	1238	1302	1367	1432	1497	1563	1630	1697	1765
13	986	1049	1112	1175	1239	1303	1368	1433	1498	1564	1631	1698	1766
14	987	1050	1113	1176	1240	1304	1369	1434	1499	1565	1632	1699	1767
15	988	1051	1114	1177	1241	1305	1370	1435	1500	1567	1633	1700	1768
16	989	1052	1115	1178	1242	1306	1371	1436	1502	1568	1634	1701	1769
17	990	1053	1116	1179	1243	1307	1372	1437	1503	1569	1635	1703	1770
18	991	1054	1117	1181	1244	1308	1373	1438	1504	1570	1637	1704	1772
19	993	1055	1118	1182	1245	1310	1374	1439	1505	1571	1638	1705	1773
20	994	1056	1119	1183	1246	1311	1375	1440	1506	1572	1639	1706	1774
21	995	1057	1120	1184	1248	1312	1376	1441	1507	1573	1640	1707	1775
22	996	1058	1121	1185	1249	1313	1377	1443	1508	1574	1641	1708	1776
23	997	1059	1122	1186	1250	1314	1379	1444	1509	1575	1642	1709	1777
24	998	1060	1123	1187	1251	1315	1380	1445	1510	1577	1643	1711	1778
25	999	1061	1125	1188	1252	1316	1381	1446	1511	1578	1644	1712	1780
26	1000	1063	1126	1189	1253	1317	1382	1447	1513	1579	1645	1713	1781
27	1001	1064	1127	1190	1254	1318	1383	1448	1514	1580	1647	1714	1782
28	1002	1065	1128	1191	1255	1319	1384	1449	1515	1581	1648	1715	1783
29	1003	1066	1129	1192	1256	1320	1385	1450	1516	1582	1649	1716	1784
30	1004	1067	1130	1193	1257	1321	1386	1451	1517	1583	1650	1717	1785
31	1005	1068	1131	1194	1258	1322	1387	1452	1518	1584	1651	1718	1786
32	1006	1069	1132	1195	1259	1324	1388	1453	1519	1585	1652	1720	1787
33	1007	1070	1133	1196	1260	1325	1389	1455	1520	1586	1653	1721	1789
34	1008	1071	1134	1198	1261	1326	1390	1456	1521	1588	1654	1722	1790
35	1009	1072	1135	1199	1262	1327	1392	1457	1522	1589	1656	1723	1791
36	1010	1073	1136	1200	1264	1328	1393	1458	1524	1590	1657	1724	1792
37	1011	1074	1137	1201	1265	1329	1394	1459	1525	1591	1658	1725	1793
38	1012	1075	1138	1202	1266	1330	1395	1460	1526	1592	1659	1726	1794
39	1013	1076	1139	1203	1267	1331	1396	1461	1527	1593	1660	1727	1795
40	1014	1077	1140	1204	1268	1332	1397	1462	1528	1594	1661	1729	1797
41	1015	1078	1141	1205	1269	1333	1398	1463	1529	1595	1662	1730	1798
42	1016	1079	1142	1206	1270	1334	1399	1464	1530	1596	1663	1731	1799
43	1018	1080	1144	1207	1271	1335	1400	1465	1531	1598	1664	1732	1800
44	1019	1081	1145	1208	1272	1336	1401	1467	1532	1599	1666	1733	1801
45	1020	1082	1146	1209	1273	1338	1402	1468	1533	1600	1667	1734	1802
46	1021	1084	1147	1210	1274	1339	1403	1469	1535	1601	1668	1735	1803
47	1022	1085	1148	1211	1275	1340	1405	1470	1536	1602	1669	1736	1805
48	1023	1086	1149	1212	1276	1341	1406	1471	1537	1603	1670	1738	1806
49	1024	1087	1150	1213	1277	1342	1407	1472	1538	1604	1671	1739	1807
50	1025	1088	1151	1215	1278	1343	1408	1473	1539	1605	1672	1740	1808
51	1026	1089	1152	1216	1280	1344	1409	1474	1540	1606	1673	1741	1809
52	1027	1090	1153	1217	1281	1345	1410	1475	1541	1608	1675	1742	1810
53	1028	1091	1154	1218	1282	1346	1411	1476	1542	1609	1676	1743	1811
54	1029	1092	1155	1219	1283	1347	1412	1477	1543	1610	1677	1744	1813
55	1030	1093	1156	1220	1284	1348	1413	1479	1544	1611	1678	1746	1814
56	1031	1094	1157	1221	1285	1349	1414	1480	1546	1612	1679	1747	1815
57	1032	1095	1158	1222	1286	1350	1415	1481	1547	1613	1680	1748	1816
58	1033	1096	1159	1223	1287	1352	1416	1482	1548	1614	1681	1749	1817
59	1034	1097	1160	1224	1288	1353	1418	1483	1549	1615	1682	1750	1818

TABLE III.

MERIDIONAL PARTS.

′	29°	30°	31°	32°	33°	34°	35°	36°	37°	38°	39°	40°	41°
0	1819	1888	1958	2028	2100	2171	2244	2318	2393	2468	2545	2623	2702
1	1821	1890	1959	2030	2101	2173	2246	2319	2394	2570	2546	2624	2703
2	1822	1891	1960	2031	2102	2174	2247	2320	2395	2471	2548	2625	2704
3	1823	1892	1962	2032	2103	2175	2248	2322	2396	2472	2549	2627	2706
4	1824	1893	1963	2033	2104	2176	2249	2323	2398	2473	2550	2628	2707
5	1825	1894	1964	2034	2105	2178	2250	2324	2399	2475	2551	2629	2708
6	1826	1895	1965	2035	2107	2179	2252	2325	2400	2476	2553	2631	2710
7	1827	1896	1966	2037	2108	2180	2253	2327	2401	2477	2554	2632	2711
8	1829	1898	1967	2038	2109	2181	2254	2328	2403	2478	2555	2633	2712
9	1830	1899	1969	2039	2110	2182	2255	2329	2404	2480	2557	2634	2714
10	1831	1900	1970	2040	2111	2184	2257	2330	2405	2481	2558	2636	2715
11	1832	1901	1971	2041	2113	2185	2258	2332	2406	2482	2559	2637	2716
12	1833	1902	1972	2043	2114	2186	2259	2333	2408	2484	2560	2638	2718
13	1834	1903	1973	2044	2115	2187	2260	2334	2409	2485	2562	2640	2719
14	1835	1905	1974	2045	2116	2188	2261	2335	2410	2486	2563	2641	2720
15	1837	1906	1976	2046	2117	2190	2263	2337	2411	2487	2564	2642	2722
16	1838	1907	1977	2047	2119	2191	2264	2338	2413	2489	2566	2644	2723
17	1839	1908	1978	2048	2120	2192	2265	2339	2414	2490	2567	2645	2724
18	1840	1909	1979	2050	2121	2193	2266	2340	2415	2491	2568	2646	2726
19	1841	1910	1980	2051	2122	2194	2268	2342	2416	2492	2569	2648	2727
20	1842	1912	1981	2052	2123	2196	2269	2343	2418	2494	2571	2649	2728
21	1843	1913	1983	2053	2125	2197	2270	2344	2419	2495	2572	2650	2729
22	1845	1914	1984	2054	2126	2198	2271	2345	2420	2496	2573	2651	2731
23	1846	1915	1985	2056	2127	2199	2272	2346	2422	2498	2575	2653	2732
24	1847	1916	1986	2057	2128	2200	2274	2348	2423	2499	2576	2654	2733
25	1848	1917	1987	2058	2129	2202	2275	2349	2424	2500	2577	2655	2735
26	1849	1918	1988	2059	2131	2203	2276	2350	2425	2501	2578	2657	2736
27	1850	1920	1990	2060	2132	2204	2277	2351	2427	2503	2580	2658	2737
28	1852	1921	1991	2061	2133	2205	2279	2353	2428	2504	2581	2659	2739
29	1853	1922	1992	2063	2134	2207	2280	2354	2429	2505	2582	2661	2740
30	1854	1923	1993	2064	2135	2208	2281	2355	2430	2506	2584	2662	2742
31	1855	1924	1994	2065	2137	2209	2282	2356	2432	2508	2585	2663	2743
32	1856	1925	1995	2066	2138	2210	2283	2358	2433	2509	2586	2665	2744
33	1857	1927	1997	2067	2139	2211	2285	2359	2434	2510	2588	2666	2746
34	1858	1928	1998	2069	2140	2213	2286	2360	2435	2512	2589	2667	2747
35	1860	1929	1999	2070	2141	2214	2287	2361	2437	2513	2590	2669	2748
36	1861	1930	2000	2071	2143	2215	2288	2363	2438	2514	2591	2670	2750
37	1862	1931	2001	2072	2144	2216	2290	2364	2439	2515	2593	2671	2751
38	1863	1932	2002	2073	2145	2217	2291	2365	2440	2517	2594	2673	2752
39	1864	1934	2004	2075	2146	2219	2292	2366	2442	2518	2595	2674	2754
40	1865	1935	2005	2076	2147	2220	2293	2368	2443	2519	2597	2675	2755
41	1866	1936	2006	2077	2149	2221	2295	2369	2444	2521	2598	2676	2756
42	1868	1937	2007	2078	2150	2222	2296	2370	2445	2522	2599	2678	2758
43	1869	1938	2008	2079	2151	2224	2297	2371	2447	2523	2601	2679	2759
44	1870	1939	2010	2080	2152	2225	2298	2373	2448	2524	2602	2680	2760
45	1871	1941	2011	2082	2153	2226	2299	2374	2449	2526	2603	2682	2762
46	1872	1942	2012	2083	2155	2227	2301	2375	2451	2527	2604	2683	2763
47	1873	1943	2013	2084	2156	2228	2302	2376	2452	2528	2606	2684	2764
48	1875	1944	2014	2085	2157	2230	2303	2378	2453	2530	2607	2686	2766
49	1876	1945	2015	2086	2158	2231	2304	2379	2454	2531	2608	2687	2767
50	1877	1946	2017	2088	2159	2232	2306	2380	2456	2532	2610	2688	2768
51	1878	1948	2018	2089	2161	2233	2307	2381	2457	2533	2611	2690	2770
52	1879	1949	2019	2090	2162	2235	2308	2383	2458	2535	2612	2691	2771
53	1880	1950	2020	2091	2163	2236	2309	2384	2459	2536	2614	2692	2772
54	1881	1951	2021	2092	2164	2237	2311	2385	2461	2537	2615	2694	2774
55	1883	1952	2022	2094	2165	2238	2312	2386	2462	2538	2616	2695	2775
56	1884	1953	2024	2095	2167	2239	2313	2388	2463	2540	2617	2696	2776
57	1885	1955	2025	2096	2168	2241	2314	2389	2464	2541	2619	2698	2778
58	1886	1956	2026	2097	2169	2242	2316	2390	2466	2542	2620	2699	2779
59	1887	1957	2027	2098	2170	2243	2317	2391	2467	2544	2621	2700	2780

MERIDIONAL PARTS.

′	42°	43°	44°	45°	46°	47°	48°	49°	50°	51°	52°	53°	54°
0	2782	2863	2946	3030	3116	3203	3292	3382	3474	3569	3665	3764	3865
1	2783	2864	2947	3031	3117	3204	3293	3384	3476	3570	3667	3765	3866
2	2784	2866	2949	3033	3118	3206	3295	3385	3478	3572	3668	3767	3868
3	2786	2867	2950	3034	3120	3207	3296	3387	3479	3574	3670	3769	3870
4	2787	2869	2951	3036	3121	3209	3298	3388	3481	3575	3672	3770	3871
5	2788	2870	2953	3037	3123	3210	3299	3390	3482	3577	3673	3772	3873
6	2790	2871	2954	3038	3124	3212	3301	3391	3484	3578	3675	3774	3875
7	2791	2873	2956	3040	3126	3213	3302	3393	3485	3580	3677	3775	3877
8	2792	2874	2957	3041	3127	3214	3303	3394	3487	3582	3678	3777	3878
9	2794	2875	2958	3043	3129	3216	3305	3396	3488	3583	3680	3779	3880
10	2795	2877	2960	3044	3130	3217	3306	3397	3490	3585	3681	3780	3882
11	2797	2878	2961	3046	3131	3219	3308	3399	3492	3586	3683	3782	3883
12	2798	2880	2963	3047	3133	3220	3309	3400	3493	3588	3685	3784	3885
13	2799	2881	2964	3048	3134	3222	3311	3402	3495	3590	3686	3785	3887
14	2801	2882	2965	3050	3136	3223	3312	3403	3496	3591	3688	3787	3889
15	2802	2884	2967	3051	3137	3225	3314	3405	3498	3593	3690	3789	3890
16	2803	2885	2968	3053	3139	3226	3316	3407	3499	3594	3691	3790	3892
17	2805	2886	2970	3054	3140	3228	3317	3408	3501	3596	3693	3792	3894
18	2806	2888	2971	3055	3142	3229	3319	3410	3503	3598	3695	3794	3895
19	2807	2889	2972	3057	3143	3231	3320	3411	3504	3599	3696	3795	3897
20	2809	2891	2974	3058	3144	3232	3322	3413	3506	3601	3698	3797	3899
21	2810	2892	2975	3060	3146	3234	3323	3414	3507	3602	3699	3799	3901
22	2811	2893	2976	3061	3147	3235	3325	3416	3509	3604	3701	3800	3902
23	2813	2895	2978	3063	3149	3237	3326	3417	3510	3606	3703	3802	3904
24	2814	2896	2979	3064	3150	3238	3328	3419	3512	3607	3704	3804	3906
25	2815	2897	2981	3065	3152	3240	3329	3420	3514	3609	3706	3806	3907
26	2817	2899	2982	3067	3153	3241	3331	3422	3515	3610	3708	3807	3909
27	2818	2900	2983	3068	3155	3242	3332	3423	3517	3612	3709	3809	3911
28	2820	2902	2985	3070	3156	3244	3334	3425	3518	3614	3711	3811	3913
29	2821	2903	2986	3071	3157	3245	3335	3427	3520	3615	3713	3812	3914
30	2822	2904	2988	3073	3159	3247	3337	3428	3521	3617	3714	3814	3916
31	2824	2906	2989	3074	3160	3248	3338	3430	3523	3618	3716	3816	3918
32	2825	2907	2991	3075	3162	3250	3340	3431	3525	3620	3717	3817	3919
33	2826	2908	2992	3077	3163	3251	3341	3433	3526	3622	3719	3819	3921
34	2828	2910	2993	3078	3165	3253	3343	3434	3528	3623	3721	3821	3923
35	2829	2911	2995	3080	3166	3254	3344	3436	3529	3625	3722	3822	3925
36	2830	2913	2996	3081	3168	3256	3346	3437	3531	3626	3724	3824	3926
37	2832	2914	2998	3083	3169	3257	3347	3439	3532	3628	3726	3826	3928
38	2833	2915	2999	3084	3171	3259	3349	3440	3534	3630	3727	3827	3930
39	2834	2917	3000	3085	3172	3260	3350	3442	3536	3631	3729	3829	3932
40	2836	2918	3002	3087	3173	3262	3352	3443	3537	3633	3731	3831	3933
41	2837	2919	3003	3088	3175	3263	3353	3445	3539	3634	3732	3832	3935
42	2839	2921	3005	3090	3176	3265	3355	3447	3540	3636	3734	3834	3937
43	2840	2922	3006	3091	3178	3266	3356	3448	3542	3638	3736	3836	3938
44	2841	2924	3007	3093	3179	3268	3358	3450	3543	3639	3737	3838	3940
45	2843	2925	3009	3094	3181	3269	3359	3451	3545	3641	3739	3839	3942
46	2844	2926	3010	3095	3182	3271	3361	3453	3547	3643	3741	3841	3944
47	2845	2928	3012	3097	3184	3272	3362	3454	3548	3644	3742	3843	3945
48	2847	2929	3013	3098	3185	3274	3364	3456	3550	3646	3744	3844	3947
49	2848	2931	3014	3100	3187	3275	3365	3457	3551	3647	3746	3846	3949
50	2849	2932	3016	3101	3188	3277	3367	3459	3553	3649	3747	3848	3951
51	2851	2933	3017	3103	3190	3278	3368	3460	3555	3651	3749	3849	3952
52	2852	2935	3019	3104	3191	3280	3370	3462	3556	3652	3750	3851	3954
53	2854	2936	3020	3105	3192	3281	3371	3464	3558	3654	3752	3853	3956
54	2855	2937	3021	3107	3194	3283	3373	3465	3559	3655	3754	3854	3958
55	2856	2939	3023	3108	3195	3284	3374	3467	3561	3657	3755	3856	3959
56	2858	2940	3024	3110	3197	3286	3376	3468	3562	3659	3757	3858	3961
57	2859	2942	3026	3111	3198	3287	3378	3470	3564	3660	3759	3860	3963
58	2860	2943	3027	3113	3200	3289	3379	3471	3566	3662	3760	3861	3964
59	2862	2944	3029	3114	3201	3290	3381	3473	3567	3664	3762	3863	3966

TABLE III.

MERIDIONAL PARTS.

′	55°	56°	57°	58°	59°	60°	61°	62°	63°	64°	65°	66°	67°
0	3968	4074	4183	4294	4409	4527	4649	4775	4905	5039	5179	5324	5474
1	3970	4076	4184	4296	4411	4529	4651	4777	4907	5042	5181	5326	5477
2	3971	4077	4186	4298	4413	4531	4653	4779	4909	5044	5184	5328	5479
3	3973	4079	4188	4300	4415	4533	4655	4781	4912	5046	5186	5331	5482
4	3975	4081	4190	4302	4417	4535	4657	4784	4914	5049	5188	5333	5484
5	3977	4083	4192	4304	4419	4537	4660	4786	4916	5051	5191	5336	5487
6	3978	4085	4194	4306	4421	4539	4662	4788	4918	5053	5193	5338	5489
7	3980	4086	4195	4308	4423	4541	4664	4790	4920	5055	5195	5341	5492
8	3982	4088	4197	4309	4425	4543	4666	4792	4923	5058	5198	5343	5495
9	3984	4090	4199	4311	4427	4545	4668	4794	4925	5060	5200	5346	5497
10	3985	4092	4201	4313	4429	4547	4670	4796	4927	5062	5203	5348	5500
11	3987	4094	4203	4315	4431	4549	4672	4798	4929	5065	5205	5351	5502
12	3989	4095	4205	4317	4433	4551	4674	4801	4931	5067	5207	5353	5505
13	3991	4097	4207	4319	4434	4553	4676	4803	4934	5069	5210	5356	5507
14	3992	4099	4208	4321	4436	4555	4678	4805	4936	5071	5212	5358	5510
15	3994	4101	4210	4323	4438	4557	4680	4807	4938	5074	5214	5361	5513
16	3996	4103	4212	4325	4440	4559	4682	4809	4940	5076	5217	5363	5515
17	3998	4104	4214	4327	4442	4562	4684	4811	4943	5078	5219	5366	5518
18	3999	4106	4216	4328	4444	4564	4687	4814	4945	5081	5222	5368	5520
19	4001	4108	4218	4330	4446	4566	4689	4816	4947	5083	5224	5371	5523
20	4003	4110	4220	4332	4448	4568	4691	4818	4949	5085	5226	5373	5526
21	4005	4112	4221	4334	4450	4570	4693	4820	4951	5088	5229	5376	5528
22	4006	4113	4223	4336	4452	4572	4695	4822	4954	5090	5231	5378	5531
23	4008	4115	4225	4338	4454	4574	4697	4824	4956	5092	5234	5380	5533
24	4010	4117	4227	4340	4456	4576	4699	4826	4958	5095	5236	5383	5536
25	4012	4119	4229	4342	4458	4578	4701	4829	4960	5097	5238	5385	5539
26	4014	4121	4231	4344	4460	4580	4703	4831	4963	5099	5241	5388	5541
27	4015	4122	4232	4346	4462	4582	4705	4833	4965	5102	5243	5390	5544
28	4017	4124	4234	4347	4464	4584	4707	4835	4967	5104	5246	5393	5546
29	4019	4126	4236	4349	4466	4586	4710	4837	4969	5106	5248	5395	5549
30	4021	4128	4238	4351	4468	4588	4712	4839	4972	5108	5250	5398	5552
31	4022	4130	4240	4353	4470	4590	4714	4842	4974	5111	5253	5401	5554
32	4024	4132	4242	4355	4472	4592	4716	4844	4976	5113	5255	5403	5557
33	4026	4133	4244	4357	4474	4594	4718	4846	4978	5115	5258	5406	5559
34	4028	4135	4246	4359	4476	4596	4720	4848	4981	5118	5260	5408	5562
35	4029	4137	4247	4361	4478	4598	4722	4850	4983	5120	5263	5411	5565
36	4031	4139	4249	4363	4480	4600	4724	4852	4985	5122	5265	5413	5567
37	4033	4141	4251	4365	4482	4602	4726	4855	4987	5125	5267	5416	5570
38	4035	4142	4253	4367	4484	4604	4728	4857	4990	5127	5270	5418	5573
39	4037	4144	4255	4369	4486	4606	4731	4859	4992	5129	5272	5421	5575
40	4038	4146	4257	4370	4488	4608	4733	4861	4994	5132	5275	5423	5578
41	4040	4148	4259	4372	4490	4610	4735	4863	4996	5134	5277	5426	5580
42	4042	4150	4260	4374	4492	4612	4737	4865	4999	5136	5280	5428	5583
43	4044	4152	4262	4376	4494	4614	4739	4868	5001	5139	5282	5431	5586
44	4045	4153	4264	4378	4495	4616	4741	4870	5003	5141	5284	5433	5588
45	4047	4155	4266	4380	4497	4618	4743	4872	5005	5143	5287	5436	5591
46	4049	4157	4268	4382	4499	4620	4745	4874	5008	5146	5289	5438	5594
47	4051	4159	4270	4384	4501	4623	4747	4876	5010	5148	5292	5441	5596
48	4052	4161	4272	4386	4503	4625	4750	4879	5012	5151	5294	5443	5599
49	4054	4162	4274	4388	4505	4627	4752	4881	5014	5153	5297	5446	5602
50	4056	4164	4275	4390	4507	4629	4754	4883	5017	5155	5299	5448	5604
51	4058	4166	4277	4392	4509	4631	4756	4885	5019	5158	5301	5451	5607
52	4060	4168	4279	4394	4511	4633	4758	4887	5021	5160	5304	5454	5610
53	4061	4170	4281	4396	4513	4635	4760	4890	5023	5162	5306	5456	5612
54	4063	4172	4283	4398	4515	4637	4762	4892	5026	5165	5309	5459	5615
55	4065	4173	4285	4399	4517	4639	4764	4894	5028	5167	5311	5461	5617
56	4067	4175	4287	4401	4519	4641	4766	4896	5030	5169	5314	5464	5620
57	4069	4177	4289	4403	4521	4643	4769	4898	5033	5172	5316	5466	5623
58	4070	4179	4291	4405	4523	4645	4771	4901	5035	5174	5319	5469	5625
59	4072	4181	4292	4407	4525	4647	4773	4903	5037	5176	5321	5471	5628

MERIDIONAL PARTS.

′	68°	69°	70°	71°	72°	73°	74°	75°	76°	77°	78°	79°	80°
0	5631	5795	5966	6146	6335	6534	6746	6970	7210	7467	7745	8046	8375
1	5633	5797	5969	6149	6338	6538	6749	6974	7214	7472	7749	8051	8381
2	5636	5800	5972	6152	6341	6541	6753	6978	7218	7476	7754	8056	8387
3	5639	5803	5975	6155	6345	6545	6757	6982	7222	7481	7759	8061	8393
4	5642	5806	5978	6158	6348	6548	6760	6986	7227	7485	7764	8067	8398
5	5644	5809	5981	6161	6351	6552	6764	6990	7231	7490	7769	8072	8404
6	5647	5811	5984	6164	6354	6555	6768	6994	7235	7494	7774	8077	8410
7	5650	5814	5986	6167	6358	6558	6771	6997	7239	7498	7778	8083	8416
8	5652	5817	5989	6170	6361	6562	6775	7001	7243	7503	7783	8088	8422
9	5655	5820	5992	6173	6364	6565	6779	7005	7247	7507	7788	8093	8427
10	5658	5823	5995	6177	6367	6569	6782	7009	7252	7512	7793	8099	8433
11	5660	5825	5998	6180	6371	6572	6786	7013	7256	7516	7798	8104	8439
12	5663	5828	6001	6183	6374	6576	6790	7017	7260	7521	7803	8109	8445
13	5666	5831	6004	6186	6377	6579	6793	7021	7264	7525	7808	8115	8451
14	5668	5834	6007	6189	6380	6583	6797	7025	7268	7530	7813	8120	8457
15	5671	5837	6010	6192	6384	6586	6801	7029	7273	7535	7817	8125	8463
16	5674	5839	6013	6195	6387	6590	6804	7033	7277	7539	7822	8131	8469
17	5676	5842	6016	6198	6390	6593	6808	7037	7281	7544	7827	8136	8474
18	5679	5845	6019	6201	6394	6597	6812	7041	7285	7548	7832	8141	8480
19	5682	5848	6022	6205	6397	6600	6815	7045	7289	7553	7837	8147	8486
20	5685	5851	6025	6208	6400	6603	6819	7048	7294	7557	7842	8152	8492
21	5687	5854	6028	6211	6403	6607	6823	7052	7298	7562	7847	8158	8498
22	5690	5856	6031	6214	6407	6610	6826	7056	7302	7566	7852	8163	8504
23	5693	5859	6034	6217	6410	6614	6830	7060	7306	7571	7857	8168	8510
24	5695	5862	6037	6220	6413	6617	6834	7064	7311	7576	7862	8174	8516
25	5698	5865	6040	6223	6417	6621	6838	7068	7315	7580	7867	8179	8522
26	5701	5868	6043	6226	6420	6624	6841	7072	7319	7585	7872	8185	8528
27	5704	5871	6046	6230	6423	6628	6845	7076	7323	7589	7877	8190	8534
28	5706	5874	6049	6233	6427	6631	6849	7080	7328	7594	7882	8196	8540
29	5709	5876	6052	6236	6430	6635	6853	7084	7332	7599	7887	8201	8546
30	5712	5879	6055	6239	6433	6639	6856	7088	7336	7603	7892	8207	8552
31	5715	5882	6058	6242	6437	6642	6860	7092	7341	7608	7897	8212	8558
32	5717	5885	6061	6245	6440	6646	6864	7096	7345	7612	7902	8218	8565
33	5720	5888	6064	6249	6443	6649	6868	7100	7349	7617	7907	8223	8571
34	5723	5891	6067	6252	6447	6653	6871	7104	7353	7622	7912	8229	8577
35	5725	5894	6070	6255	6450	6656	6875	7108	7358	7626	7917	8234	8583
36	5728	5896	6073	6258	6453	6660	6879	7112	7362	7631	7922	8240	8589
37	5731	5899	6076	6261	6457	6663	6883	7116	7366	7636	7927	8245	8595
38	5734	5902	6079	6264	6460	6667	6886	7120	7371	7640	7932	8251	8601
39	5736	5905	6082	6268	6463	6670	6890	7124	7375	7645	7937	8256	8607
40	5739	5908	6085	6271	6467	6674	6894	7128	7379	7650	7942	8262	8614
41	5742	5911	6088	6274	6470	6677	6898	7132	7384	7654	7948	8267	8620
42	5745	5914	6091	6277	6473	6681	6901	7136	7388	7659	7953	8273	8626
43	5747	5917	6094	6280	6477	6685	6905	7140	7392	7664	7958	8279	8632
44	5750	5919	6097	6283	6480	6688	6909	7145	7397	7668	7963	8284	8638
45	5753	5922	6100	6287	6483	6692	6913	7149	7401	7673	7968	8290	8644
46	5756	5925	6103	6290	6487	6695	6917	7153	7406	7678	7973	8295	8651
47	5758	5928	6106	6293	6490	6699	6920	7157	7410	7683	7978	8301	8657
48	5761	5931	6109	6296	6494	6702	6924	7161	7414	7687	7983	8307	8663
49	5764	5934	6112	6299	6497	6706	6928	7165	7419	7692	7989	8312	8669
50	5767	5937	6115	6303	6500	6710	6932	7169	7423	7697	7994	8318	8676
51	5770	5940	6118	6306	6504	6713	6936	7173	7427	7702	7999	8324	8682
52	5772	5943	6121	6309	6507	6717	6940	7177	7432	7706	8004	8329	8688
53	5775	5946	6124	6312	6511	6720	6943	7181	7436	7711	8009	8335	8695
54	5778	5948	6127	6315	6514	6724	6947	7185	7441	7716	8014	8341	8701
55	5781	5951	6130	6319	6517	6728	6951	7189	7445	7721	8020	8347	8707
56	5783	5954	6133	6322	6521	6731	6955	7194	7449	7725	8025	8352	8714
57	5786	5957	6136	6325	6524	6735	6959	7198	7454	7730	8030	8358	8720
58	5789	5960	6140	6328	6528	6738	6963	7202	7458	7735	8035	8364	8726
59	5792	5963	6143	6332	6531	6742	6966	7206	7463	7740	8040	8369	8733

TABLE III.

MERIDIONAL PARTS.

′	81°	82°	83°	84°	85°
0	8739	9145	9606	10137	10765
1	8745	9153	9614	10146	10776
2	8752	9160	9622	10156	10788
3	8758	9167	9631	10166	10799
4	8765	9174	9639	10175	10811
5	8771	9182	9647	10185	10822
6	8778	9189	9655	10195	10834
7	8784	9196	9664	10205	10846
8	8791	9203	9672	10214	10858
9	8797	9211	9680	10224	10869
10	8804	9218	9689	10234	10881
11	8810	9225	9697	10244	10893
12	8817	9233	9706	10254	10905
13	8823	9240	9714	10264	10917
14	8830	9248	9723	10273	10929
15	8836	9255	9731	10283	10941
16	8843	9262	9740	10293	10953
17	8849	9270	9748	10303	10965
18	8856	9277	9757	10314	10978
19	8863	9285	9765	10324	10990
20	8869	9292	9774	10334	11002
21	8876	9300	9783	10344	11014
22	8883	9307	9791	10354	11027
23	8889	9315	9800	10364	11039
24	8896	9322	9809	10374	11052
25	8903	9330	9817	10385	11064
26	8909	9337	9826	10395	11077
27	8916	9345	9835	10405	11089
28	8923	9353	9844	10416	11102
29	8930	9360	9852	10426	11115
30	8936	9368	9861	10437	11127
31	8943	9376	9870	10447	11140
32	8950	9383	9879	10457	11153
33	8957	9391	9888	10468	11166
34	8963	9399	9897	10479	11179
35	8970	9407	9906	10489	11192
36	8977	9414	9915	10500	11205
37	8984	9422	9924	10510	11218
38	8991	9430	9933	10521	11231
39	8998	9438	9942	10532	11244
40	9005	9445	9951	10542	11257
41	9012	9453	9960	10553	11270
42	9018	9461	9969	10564	11284
43	9025	9469	9978	10575	11297
44	9032	9477	9987	10586	11310
45	9039	9485	9996	10597	11324
46	9046	9493	10005	10608	11337
47	9053	9501	10015	10619	11351
48	9060	9509	10024	10630	11365
49	9067	9517	10033	10641	11378
50	9074	9525	10043	10652	11392
51	9081	9533	10052	10663	11406
52	9088	9541	10061	10674	11420
53	9096	9549	10071	10685	11434
54	9103	9557	10080	10696	11448
55	9110	9565	10089	10708	11462
56	9117	9573	10099	10719	11476
57	9124	9581	10108	10730	11490
58	9131	9589	10118	10742	11504
59	9138	9598	10127	10753	11518

TABLE IV.

LOGARITHMIC SINES, TANGENTS, AND SECANTS, to every Point and Quarter Point of the Compass.

Points.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-sec.	Points.
0	0.000000	10.000000	0.000000	Infinite.	10.000000	Infinite.	8
0 ¼	8.690796	9.999477	8.691319	11.308681	10.000523	11.309204	7 ¾
0 ½	8.991302	9.997904	8.993398	11.006602	10.002096	11.008698	7 ½
0 ¾	9.166520	9.995274	9.171247	10.828753	10.004726	10.833480	7 ¼
1	9.290236	9.991574	9.298662	10.701338	10.008426	10.709764	7
1 ¼	9.385571	9.986786	9.398785	10.601215	10.013214	10.614429	6 ¾
1 ½	9.462824	9.980885	9.481939	10.518061	10.019115	10.537176	6 ½
1 ¾	9.527488	9.973841	9.553647	10.446353	10.026159	10.472512	6 ¼
2	9.582840	9.965615	9.617224	10.382776	10.034385	10.417160	6
2 ¼	9.630992	9.956163	9.674829	10.325171	10.043837	10.369008	5 ¾
2 ½	9.673387	9.945430	9.727957	10.272043	10.054570	10.326613	5 ½
2 ¾	9.711050	9.933350	9.777700	10.222300	10.066650	10.288950	5 ¼
3	9.744739	9.919846	9.824893	10.175107	10.080154	10.255261	5
3 ¼	9.775027	9.904828	9.870199	10.129801	10.095172	10.224973	4 ¾
3 ½	9.802359	9.888185	9.914173	10.085827	10.111815	10.197641	4 ½
3 ¾	9.827084	9.869790	9.957295	10.042705	10.130210	10.172916	4 ¼
4	9.849485	9.849485	10.000000	10.000000	10.150515	10.150515	4
	Co-sine.	Sine.	Co-tang.	Tangent.	Co-sec.	Secant.	

TABLE V.

LOGARITHMS OF NUMBERS.

No.	Log.	No.	Log.	No.	Log.	No.	Log.	No.	Log.
1	0.000000	21	1.322219	41	1.612784	61	1.785330	81	1.908485
2	0.301030	22	1.342423	42	1.623249	62	1.792392	82	1.913814
3	0.477121	23	1.361728	43	1.633468	63	1.799341	83	1.919078
4	0.602060	24	1.380211	44	1.643453	64	1.806180	84	1.924279
5	0.698970	25	1.397940	45	1.653213	65	1.812913	85	1.929419
6	0.778151	26	1.414973	46	1.662758	66	1.819544	86	1.934498
7	0.845098	27	1.431364	47	1.672098	67	1.826075	87	1.939519
8	0.903090	28	1.447158	48	1.681241	68	1.832509	88	1.944483
9	0.954243	29	1.462398	49	1.690196	69	1.838849	89	1.949390
10	1.000000	30	1.477121	50	1.698970	70	1.845098	90	1.954243
11	1.041393	31	1.491362	51	1.707570	71	1.851258	91	1.959041
12	1.079181	32	1.505150	52	1.716003	72	1.857332	92	1.963788
13	1.113943	33	1.518514	53	1.724276	73	1.863323	93	1.968483
14	1.146128	34	1.531479	54	1.732394	74	1.869232	94	1.973128
15	1.176091	35	1.544068	55	1.740363	75	1.875061	95	1.977724
16	1.204120	36	1.556302	56	1.748188	76	1.880814	96	1.982271
17	1.230449	37	1.568202	57	1.755875	77	1.886491	97	1.986772
18	1.255273	38	1.579784	58	1.763428	78	1.892095	98	1.991226
19	1.278754	39	1.591065	59	1.770852	79	1.897627	99	1.995635
20	1.301030	40	1.602060	60	1.778151	80	1.903090	100	2.000000

Logarithms from 1 to 10,000.

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100	000000	000434	000868	001301	001734	002166	002598	003029	003461	003891	432
101	4321	4751	5181	5609	6038	6466	6894	7321	7748	8174	428
102	8600	9026	9451	9876	010300	010724	011147	011570	011993	012415	424
103	012837	013259	013680	014100	4521	4940	5360	5779	6197	6616	419
104	7033	7451	7868	8284	8700	9116	9532	9947	020361	020775	416
105	021189	021603	022016	022428	022841	023252	023664	024075	4486	4896	412
106	5306	5715	6125	6533	6942	7350	7757	8164	8571	8978	408
107	9384	9789	030195	030600	031004	031408	031812	032216	032619	033021	404
108	033424	033826	4227	4628	5029	5430	5830	6230	6629	7028	400
109	7426	7825	8223	8620	9017	9414	9811	040207	040602	040998	396
110	041393	041787	042182	042576	042969	043362	043755	044148	044540	044932	393
111	5323	5714	6105	6495	6885	7275	7664	8053	8442	8830	389
112	9218	9606	9993	050380	050766	051153	051538	051924	052309	052694	386
113	053078	053463	053846	4230	4613	4996	5378	5760	6142	6524	382
114	6905	7286	7666	8046	8426	8805	9185	9563	9942	060320	379
115	060698	061075	061452	061829	062206	062582	062958	063333	063709	4083	376
116	4458	4832	5206	5580	5953	6326	6699	7071	7443	7815	372
117	8186	8557	8928	9298	9668	070038	070407	070776	071145	071514	369
118	071882	072250	072617	072985	073352	3718	4085	4451	4816	5182	366
119	5547	5912	6276	6640	7004	7368	7731	8094	8457	8819	363
120	079181	079543	079904	080266	080626	080987	081347	081707	082067	082426	360
121	082785	083144	083503	3861	4219	4576	4934	5291	5647	6004	357
122	6360	6716	7071	7426	7781	8136	8490	8845	9198	9552	355
123	9905	090258	090611	090963	091315	091667	092018	092370	092721	093071	351
124	093422	3772	4122	4471	4820	5169	5518	5866	6215	6562	349
125	6910	7257	7604	7951	8298	8644	8990	9335	9681	100026	346
126	100371	100715	101059	101403	101747	102091	102434	102777	103119	3462	343
127	3804	4146	4487	4828	5169	5510	5851	6191	6531	6871	340
128	7210	7549	7888	8227	8565	8903	9241	9579	9916	110253	338
129	110590	110926	111263	111599	111934	112270	112605	112940	113275	3609	335
130	113943	114277	114611	114944	115278	115611	115943	116276	116608	116940	333
131	7271	7603	7934	8265	8595	8926	9256	9586	9915	120245	330
132	120574	120903	121231	121560	121888	122216	122544	122871	123198	3525	328
133	3852	4178	4504	4830	5156	5481	5806	6131	6456	6781	325
134	7105	7429	7753	8076	8399	8722	9045	9368	9690	130012	323
135	130334	130655	130977	131298	131619	131939	132260	132580	132900	3219	321
136	3539	3858	4177	4496	4814	5133	5451	5769	6086	6403	318
137	6721	7037	7354	7671	7987	8303	8618	8934	9249	9564	315
138	9879	140194	140508	140822	141136	141450	141763	142076	142389	142702	314
139	143015	3327	3639	3951	4263	4574	4885	5196	5507	5818	311
140	146128	146438	146748	147058	147367	147676	147985	148294	148603	148911	309
141	9219	9527	9835	150142	150449	150756	151063	151370	151676	151982	307
142	152288	152594	152900	3205	3510	3815	4120	4424	4728	5032	305
143	5336	5640	5943	6246	6549	6852	7154	7457	7759	8061	303
144	8362	8664	8965	9266	9567	9868	160168	160469	160769	161068	301
145	161368	161667	161967	162266	162564	162863	3161	3460	3758	4055	299
146	4353	4650	4947	5244	5541	5838	6134	6430	6726	7022	297
147	7317	7613	7908	8203	8497	8792	9086	9380	9674	9968	295
148	170262	170555	170848	171141	171434	171726	172019	172311	172603	172895	293
149	3186	3478	3769	4060	4351	4641	4932	5222	5512	5802	291
150	176091	176381	176670	176959	177248	177536	177825	178113	178401	178689	289
151	8977	9264	9552	9839	180126	180413	180699	180986	181272	181558	287
152	181844	182129	182415	182700	2985	3270	3555	3839	4123	4407	285
153	4691	4975	5259	5542	5825	6108	6391	6674	6956	7239	283
154	7521	7803	8084	8366	8647	8928	9209	9490	9771	190051	281
155	190332	190612	190892	191171	191451	191730	192010	192289	192567	2846	279
156	3125	3403	3681	3959	4237	4514	4792	5069	5346	5623	278
157	5900	6176	6453	6729	7005	7281	7556	7832	8107	8382	276
158	8657	8932	9206	9481	9755	200029	200303	200577	200850	201124	274
159	201397	201670	201943	202216	202488	2761	3033	3305	3577	3848	272
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Logarithms from 1 to 10,000.

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160	204120	204391	204663	204934	205204	205475	205746	206016	206286	206556	271
161	6826	7096	7365	7634	7904	8173	8441	8710	8979	9247	269
162	9515	9783	210051	210319	210586	210853	211121	211388	211654	211921	267
163	212188	212454	2720	2986	3252	3518	3783	4049	4314	4579	266
164	4844	5109	5373	5638	5902	6166	6430	6694	6957	7221	264
165	7484	7747	8010	8273	8536	8798	9060	9323	9585	9846	262
166	220108	220370	220631	220892	221153	221414	221675	221936	222196	222456	261
167	2716	2976	3236	3496	3755	4015	4274	4533	4792	5051	259
168	5309	5568	5826	6084	6342	6600	6858	7115	7372	7630	258
169	7887	8144	8400	8657	8913	9170	9426	9682	9938	230193	256
170	230449	230704	230960	231215	231470	231724	231979	232234	232488	232742	255
171	2996	3250	3504	3757	4011	4264	4517	4770	5023	5276	253
172	5528	5781	6033	6285	6537	6789	7041	7292	7544	7795	252
173	8046	8297	8548	8799	9049	9299	9550	9800	240050	240300	250
174	240549	240799	241048	241297	241546	241795	242044	242293	2541	2790	249
175	3038	3286	3534	3782	4030	4277	4525	4772	5019	5266	248
176	5513	5759	6006	6252	6499	6745	6991	7237	7482	7728	246
177	7973	8219	8464	8709	8954	9198	9443	9687	9932	250176	245
178	250420	250664	250908	251151	251395	251638	251881	252125	252368	2610	243
179	2853	3096	3338	3580	3822	4064	4306	4548	4790	5031	242
180	255273	255514	255755	255996	256237	256477	256718	256958	257198	257439	241
181	7679	7918	8158	8398	8637	8877	9116	9355	9594	9833	239
182	260071	260310	260548	260787	261025	261263	261501	261739	261976	262214	238
183	2451	2688	2925	3162	3399	3636	3873	4109	4346	4582	237
184	4818	5054	5290	5525	5761	5996	6232	6467	6702	6937	235
185	7172	7406	7641	7875	8110	8344	8578	8812	9046	9279	234
186	9513	9746	9980	270213	270446	270679	270912	271144	271377	271609	233
187	271842	272074	272306	2538	2770	3001	3233	3464	3696	3927	232
188	4158	4389	4620	4850	5081	5311	5542	5772	6002	6232	230
189	6462	6692	6921	7151	7380	7609	7838	8067	8296	8525	229
190	278754	278982	279211	279439	279667	279895	280123	280351	280578	280806	228
191	281033	281261	281488	281715	281942	282169	2396	2622	2849	3075	227
192	3301	3527	3753	3979	4205	4431	4656	4882	5107	5332	226
193	5557	5782	6007	6232	6456	6681	6905	7130	7354	7578	225
194	7802	8026	8249	8473	8696	8920	9143	9366	9589	9812	223
195	290035	290257	290480	290702	290925	291147	291369	291591	291813	292034	222
196	2256	2478	2699	2920	3141	3363	3584	3804	4025	4246	221
197	4466	4687	4907	5127	5347	5567	5787	6007	6226	6446	220
198	6665	6884	7104	7323	7542	7761	7979	8198	8416	8635	219
199	8853	9071	9289	9507	9725	9943	300161	300378	300595	300813	218
200	301030	301247	301464	301681	301898	302114	302331	302547	302764	302980	217
201	3196	3412	3628	3844	4059	4275	4491	4706	4921	5136	216
202	5351	5566	5781	5996	6211	6425	6639	6854	7068	7282	215
203	7496	7710	7924	8137	8351	8564	8778	8991	9204	9417	213
204	9630	9843	310056	310268	310481	310693	310906	311118	311330	311542	212
205	311754	311966	2177	2389	2600	2812	3023	3234	3445	3656	211
206	3867	4078	4289	4499	4710	4920	5130	5340	5551	5760	210
207	5970	6180	6390	6599	6809	7018	7227	7436	7646	7854	209
208	8063	8272	8481	8689	8898	9106	9314	9522	9730	9938	208
209	320146	320354	320562	320769	320977	321184	321391	321598	321805	322012	207
210	322219	322426	322633	322839	323046	323252	323458	323665	323871	324077	206
211	4282	4488	4694	4899	5105	5310	5516	5721	5926	6131	205
212	6336	6541	6745	6950	7155	7359	7563	7767	7972	8176	204
213	8380	8583	8787	8991	9194	9398	9601	9805	330008	330211	203
214	330414	330617	330819	331022	331225	331427	331630	331832	2034	2236	202
215	2438	2640	2842	3044	3246	3447	3649	3850	4051	4253	202
216	4454	4655	4856	5057	5257	5458	5658	5859	6059	6260	201
217	6460	6660	6860	7060	7260	7459	7659	7858	8058	8257	200
218	8456	8656	8855	9054	9253	9451	9650	9849	340047	340246	199
219	340444	340642	340841	341039	341237	341435	341632	341830	2028	2225	198
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Logarithms from 1 to 10,000.

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220	342423	342620	342817	343014	343212	343409	343606	343802	343999	344196	197
221	4392	4589	4785	4981	5178	5374	5570	5766	5962	6157	196
222	6353	6549	6744	6939	7135	7330	7525	7720	7915	8110	195
223	8305	8500	8694	8889	9083	9278	9472	9666	9860	350054	194
224	350248	350442	350636	350829	351023	351216	351410	351603	351796	1989	193
225	2183	2375	2568	2761	2954	3147	3339	3532	3724	3916	193
226	4108	4301	4493	4685	4876	5068	5260	5452	5643	5834	192
227	6026	6217	6408	6599	6790	6981	7172	7363	7554	7744	191
228	7935	8125	8316	8506	8696	8886	9076	9266	9456	9646	190
229	9835	360025	360215	360404	360593	360783	360972	361161	361350	361539	189
230	361728	361917	362105	362294	362482	362671	362859	363048	363236	363424	188
231	3612	3800	3988	4176	4363	4551	4739	4926	5113	5301	188
232	5488	5675	5862	6049	6236	6423	6610	6796	6983	7169	187
233	7356	7542	7729	7915	8101	8287	8473	8659	8845	9030	186
234	9216	9401	9587	9772	9958	370143	370328	370513	370698	370883	185
235	371068	371253	371437	371622	371806	1991	2175	2360	2544	2728	184
236	2912	3096	3280	3464	3647	3831	4015	4198	4382	4565	184
237	4748	4932	5115	5298	5481	5664	5846	6029	6212	6394	183
238	6577	6759	6942	7124	7306	7488	7670	7852	8034	8216	182
239	8398	8580	8761	8943	9124	9306	9487	9668	9849	380030	181
240	380211	380392	380573	380754	380934	381115	381296	381476	381656	381837	181
241	2017	2197	2377	2557	2737	2917	3097	3277	3456	3636	180
242	3815	3995	4174	4353	4533	4712	4891	5070	5249	5428	179
243	5606	5785	5964	6142	6321	6499	6677	6856	7034	7212	178
244	7390	7568	7746	7924	8101	8279	8456	8634	8811	8989	178
245	9166	9343	9520	9698	9875	390051	390228	390405	390582	390759	177
246	390935	391112	391288	391464	391641	1817	1993	2169	2345	2521	176
247	2697	2873	3048	3224	3400	3575	3751	3926	4101	4277	176
248	4452	4627	4802	4977	5152	5326	5501	5676	5850	6025	175
249	6199	6374	6548	6722	6896	7071	7245	7419	7592	7766	174
250	397940	398114	398287	398461	398634	398808	398981	399154	399328	399501	173
251	9674	9847	400020	400192	400365	400538	400711	400883	401056	401228	173
252	401401	401573	1745	1917	2089	2261	2433	2605	2777	2949	172
253	3121	3292	3464	3635	3807	3978	4149	4320	4492	4663	171
254	4834	5005	5176	5346	5517	5688	5858	6029	6199	6370	171
255	6540	6710	6881	7051	7221	7391	7561	7731	7901	8070	170
256	8240	8410	8579	8749	8918	9087	9257	9426	9595	9764	169
257	9933	410102	410271	410440	410609	410777	410946	411114	411283	411451	169
258	411620	1788	1956	2124	2293	2461	2629	2796	2964	3132	168
259	3300	3467	3635	3803	3970	4137	4305	4472	4639	4806	167
260	414973	415140	415307	415474	415641	415808	415974	416141	416308	416474	167
261	6641	6807	6973	7139	7306	7472	7638	7804	7970	8135	166
262	8301	8467	8633	8798	8964	9129	9295	9460	9625	9791	165
263	9956	420121	420286	420451	420616	420781	420945	421110	421275	421439	165
264	421604	1768	1933	2097	2261	2426	2590	2754	2918	3082	164
265	3246	3410	3574	3737	3901	4065	4228	4392	4555	4718	164
266	4882	5045	5208	5371	5534	5697	5860	6023	6186	6349	163
267	6511	6674	6836	6999	7161	7324	7486	7648	7811	7973	162
268	8135	8297	8459	8621	8783	8944	9106	9268	9429	9591	162
269	9752	9914	430075	430236	430398	430559	430720	430881	431042	431203	161
270	431364	431525	431685	431846	432007	432167	432328	432488	432649	432809	161
271	2969	3130	3290	3450	3610	3770	3930	4090	4249	4409	160
272	4569	4729	4888	5048	5207	5367	5526	5685	5844	6004	159
273	6163	6322	6481	6640	6799	6957	7116	7275	7433	7592	159
274	7751	7909	8067	8226	8384	8542	8701	8859	9017	9175	158
275	9333	9491	9648	9806	9964	440122	440279	440437	440594	440752	158
276	440909	441066	441224	441381	441538	1695	1852	2009	2166	2323	157
277	2480	2637	2793	2950	3106	3263	3419	3576	3732	3889	157
278	4045	4201	4357	4513	4669	4825	4981	5137	5293	5449	156
279	5604	5760	5915	6071	6226	6382	6537	6692	6848	7003	155
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Logarithms from 1 to 10,000.

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280	447158	447313	447468	447623	447778	447933	448088	448242	448397	448552	155
281	8706	8861	9015	9170	9324	9478	9633	9787	9941	450095	154
282	450249	450403	450557	450711	450865	451018	451172	451326	451479	1633	154
283	1786	1940	2093	2247	2400	2553	2706	2859	3012	3165	153
284	3318	3471	3624	3777	3930	4082	4235	4387	4540	4692	153
285	4845	4997	5150	5302	5454	5606	5758	5910	6062	6214	152
286	6366	6518	6670	6821	6973	7125	7276	7428	7579	7731	152
287	7882	8033	8184	8336	8487	8638	8789	8940	9091	9242	151
288	9392	9543	9694	9845	9995	460146	460296	460447	460597	460748	151
289	460898	461048	461198	461348	461499	1649	1799	1948	2098	2248	150
290	462398	462548	462697	462847	462997	463146	463296	463445	463594	463744	150
291	3893	4042	4191	4340	4490	4639	4788	4936	5085	5234	149
292	5383	5532	5680	5829	5977	6126	6274	6423	6571	6719	149
293	6868	7016	7164	7312	7460	7608	7756	7904	8052	8200	148
294	8347	8495	8643	8790	8938	9085	9233	9380	9527	9675	148
295	9822	9969	470116	470263	470410	470557	470704	470851	470998	471145	147
296	471292	471438	1585	1732	1878	2025	2171	2318	2464	2610	146
297	2756	2903	3049	3195	3341	3487	3633	3779	3925	4071	146
298	4216	4362	4508	4653	4799	4944	5090	5235	5381	5526	146
299	5671	5816	5962	6107	6252	6397	6542	6687	6832	6976	145
300	477121	477266	477411	477555	477700	477844	477989	478133	478278	478422	145
301	8566	8711	8855	8999	9143	9287	9431	9575	9719	9863	144
302	480007	480151	480294	480438	480582	480725	480869	481012	481156	481299	144
303	1443	1586	1729	1872	2016	2159	2302	2445	2588	2731	143
304	2874	3016	3159	3302	3445	3587	3730	3872	4015	4157	143
305	4300	4442	4585	4727	4869	5011	5153	5295	5437	5579	142
306	5721	5863	6005	6147	6289	6430	6572	6714	6855	6997	142
307	7138	7280	7421	7563	7704	7845	7986	8127	8269	8410	141
308	8551	8692	8833	8974	9114	9255	9396	9537	9677	9818	141
309	9958	490099	490239	490380	490520	490661	490801	490941	491081	491222	140
310	491362	491502	491642	491782	491922	492062	492201	492341	492481	492621	140
311	2760	2900	3040	3179	3319	3458	3597	3737	3876	4015	139
312	4155	4294	4433	4572	4711	4850	4989	5128	5267	5406	139
313	5544	5683	5822	5960	6099	6238	6376	6515	6653	6791	139
314	6930	7068	7206	7344	7483	7621	7759	7897	8035	8173	138
315	8311	8448	8586	8724	8862	8999	9137	9275	9412	9550	138
316	9687	9824	9962	500099	500236	500374	500511	500648	500785	500922	137
317	501059	501196	501333	1470	1607	1744	1880	2017	2154	2291	137
318	2427	2564	2700	2837	2973	3109	3246	3382	3518	3655	136
319	3791	3927	4063	4199	4335	4471	4607	4743	4878	5014	136
320	505150	505286	505421	505557	505693	505828	505964	506099	506234	506370	136
321	6505	6640	6776	6911	7046	7181	7316	7451	7586	7721	135
322	7856	7991	8126	8260	8395	8530	8664	8799	8934	9068	135
323	9203	9337	9471	9606	9740	9874	510009	510143	510277	510411	134
324	510545	510679	510813	510947	511081	511215	1349	1482	1616	1750	134
325	1883	2017	2151	2284	2418	2551	2684	2818	2951	3084	133
326	3218	3351	3484	3617	3750	3883	4016	4149	4282	4415	133
327	4548	4681	4813	4946	5079	5211	5344	5476	5609	5741	133
328	5874	6006	6139	6271	6403	6535	6668	6800	6932	7064	132
329	7196	7328	7460	7592	7724	7855	7987	8119	8251	8382	132
330	518514	518646	518777	518909	519040	519171	519303	519434	519566	519697	131
331	9828	9959	520090	520221	520353	520485	520615	520745	520876	521007	131
332	521138	521269	1400	1530	1661	1792	1922	2053	2183	2314	131
333	2444	2575	2705	2835	2966	3096	3226	3356	3486	3616	130
334	3746	3876	4006	4136	4266	4396	4526	4656	4785	4915	130
335	5045	5174	5304	5434	5563	5693	5822	5951	6081	6210	129
336	6339	6469	6598	6727	6856	6985	7114	7243	7372	7501	129
337	7630	7759	7888	8016	8145	8274	8402	8531	8660	8788	129
338	8917	9045	9174	9302	9430	9559	9687	9815	9943	530072	128
339	530200	530328	530456	530584	530712	530840	530968	531096	531223	1351	128
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Logarithms from 1 to 10,000.

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340	531479	531607	531734	531862	531990	532117	532245	532372	532500	532627	128
341	2754	2882	3009	3136	3264	3391	3518	3645	3772	3899	127
342	4026	4153	4280	4407	4534	4661	4787	4914	5041	5167	127
343	5294	5421	5547	5674	5800	5927	6053	6179	6306	6432	126
344	6558	6685	6811	6937	7063	7189	7315	7441	7567	7693	126
345	7819	7945	8071	8197	8322	8448	8574	8699	8825	8951	126
346	9076	9202	9327	9452	9578	9703	9829	9954	540079	540204	125
347	540329	540455	540580	540705	540830	540955	541080	541205	1330	1454	125
348	1579	1704	1829	1953	2078	2203	2327	2452	2576	2701	125
349	2825	2950	3074	3199	3323	3447	3571	3696	3820	3944	124
350	544068	544192	544316	544440	544564	544688	544812	544936	545060	545183	124
351	5307	5431	5555	5678	5802	5925	6049	6172	6296	6419	124
352	6543	6666	6789	6913	7036	7159	7282	7405	7529	7652	123
353	7775	7898	8021	8144	8267	8389	8512	8635	8758	8881	123
354	9003	9126	9249	9371	9494	9616	9739	9861	9984	550106	123
355	550228	550351	550473	550595	550717	550840	550962	551084	551206	1328	122
356	1450	1572	1694	1816	1938	2060	2181	2303	2425	2547	122
357	2668	2790	2911	3033	3155	3276	3398	3519	3640	3762	121
358	3883	4004	4126	4247	4368	4489	4610	4731	4852	4973	121
359	5094	5215	5336	5457	5578	5699	5820	5940	6061	6182	121
360	556303	556423	556544	556664	556785	556905	557026	557146	557267	557387	120
361	7507	7627	7748	7868	7988	8108	8228	8349	8469	8589	120
362	8709	8829	8948	9068	9188	9308	9428	9548	9667	9787	120
363	9907	560026	560146	560265	560385	560504	560624	560743	560863	560982	119
364	561101	1221	1340	1459	1578	1698	1817	1936	2055	2174	119
365	2293	2412	2531	2650	2769	2887	3006	3125	3244	3362	119
366	3481	3600	3718	3837	3955	4074	4192	4311	4429	4548	119
367	4666	4784	4903	5021	5139	5257	5376	5494	5612	5730	118
368	5848	5966	6084	6202	6320	6437	6555	6673	6791	6909	118
369	7026	7144	7262	7379	7497	7614	7732	7849	7967	8084	118
370	568202	568319	568436	568554	568671	568788	568905	569023	569140	569257	117
371	9374	9491	9608	9725	9842	9959	570076	570193	570309	570426	117
372	570543	570660	570776	570893	571010	571126	1243	1359	1476	1592	117
373	1709	1825	1942	2058	2174	2291	2407	2523	2639	2755	116
374	2872	2988	3104	3220	3336	3452	3568	3684	3800	3915	116
375	4031	4147	4263	4379	4494	4610	4726	4841	4957	5072	116
376	5188	5303	5419	5534	5650	5765	5880	5996	6111	6226	115
377	6341	6457	6572	6687	6802	6917	7032	7147	7262	7377	115
378	7492	7607	7722	7836	7951	8066	8181	8295	8410	8525	115
379	8639	8754	8868	8983	9097	9212	9326	9441	9555	9669	114
380	579784	579898	580012	580126	580241	580355	580469	580583	580697	580811	114
381	580925	581039	1153	1267	1381	1495	1608	1722	1836	1950	114
382	2063	2177	2291	2404	2518	2631	2745	2858	2972	3085	114
383	3199	3312	3426	3539	3652	3765	3879	3992	4105	4218	113
384	4331	4444	4557	4670	4783	4896	5009	5122	5235	5348	113
385	5461	5574	5686	5799	5912	6024	6137	6250	6362	6475	113
386	6587	6700	6812	6925	7037	7149	7262	7374	7486	7599	112
387	7711	7823	7935	8047	8160	8272	8384	8496	8608	8720	112
388	8832	8944	9056	9167	9279	9391	9503	9615	9726	9838	112
389	9950	590061	590173	590284	590396	590507	590619	590730	590842	590953	112
390	591065	591176	591287	591399	591510	591621	591732	591843	591955	592066	111
391	2177	2288	2399	2510	2621	2732	2843	2954	3064	3175	111
392	3286	3397	3508	3618	3729	3840	3950	4061	4171	4282	111
393	4393	4503	4614	4724	4834	4945	5055	5165	5276	5386	110
394	5496	5606	5717	5827	5937	6047	6157	6267	6377	6487	110
395	6597	6707	6817	6927	7037	7146	7256	7366	7476	7586	110
396	7695	7805	7914	8024	8134	8243	8353	8462	8572	8681	110
397	8791	8900	9009	9119	9228	9337	9446	9556	9665	9774	109
398	9883	9992	600101	600210	600319	600428	600537	600646	600755	600864	109
399	600973	601082	1191	1299	1408	1517	1625	1734	1843	1951	109
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Logarithms from 1 to 10,000.

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400	602060	602169	602277	602386	602494	602603	602711	602819	602928	603036	108
401	3144	3253	3361	3469	3577	3686	3794	3902	4010	4118	108
402	4226	4334	4442	4550	4658	4766	4874	4982	5089	5197	108
403	5305	5413	5521	5628	5736	5844	5951	6059	6166	6274	108
404	6381	6489	6596	6704	6811	6919	7026	7133	7241	7348	107
405	7455	7562	7669	7777	7884	7991	8098	8205	8312	8419	107
406	8526	8633	8740	8847	8954	9061	9167	9274	9381	9488	107
407	9594	9701	9808	9914	610021	610128	610234	610341	610447	610554	107
408	610660	610767	610873	610979	1086	1192	1298	1405	1511	1617	106
409	1723	1829	1936	2042	2148	2254	2360	2466	2572	2678	106
410	612784	612890	612996	613102	613207	613313	613419	613525	613630	613736	106
411	3842	3947	4053	4159	4264	4370	4475	4581	4686	4792	106
412	4897	5003	5108	5213	5319	5424	5529	5634	5740	5845	105
413	5950	6055	6160	6265	6370	6476	6581	6686	6790	6895	105
414	7000	7105	7210	7315	7420	7525	7629	7734	7839	7943	105
415	8048	8153	8257	8362	8466	8571	8676	8780	8884	8989	105
416	9093	9198	9302	9406	9511	9615	9719	9824	9928	620032	104
417	620136	620240	620344	620448	620552	620656	620760	620864	620968	1072	104
418	1176	1280	1384	1488	1592	1695	1799	1903	2007	2110	104
419	2214	2318	2421	2525	2628	2732	2835	2939	3042	3146	104
420	623249	623353	623456	623559	623663	623766	623869	623973	624076	624179	103
421	4282	4385	4488	4591	4695	4798	4901	5004	5107	5210	103
422	5312	5415	5518	5621	5724	5827	5929	6032	6135	6238	103
423	6340	6443	6546	6648	6751	6853	6956	7058	7161	7263	103
424	7366	7468	7571	7673	7775	7878	7980	8082	8185	8287	102
425	8389	8491	8593	8695	8797	8900	9002	9104	9206	9308	102
426	9410	9512	9613	9715	9817	9919	630021	630123	630224	630326	102
427	630428	630530	630631	630733	630835	630936	1038	1139	1241	1342	102
428	1444	1545	1647	1748	1849	1951	2052	2153	2255	2356	101
429	2457	2559	2660	2761	2862	2963	3064	3165	3266	3367	101
430	633468	633569	633670	633771	633872	633973	634074	634175	634276	634376	100
431	4477	4578	4679	4779	4880	4981	5081	5182	5283	5383	100
432	5484	5584	5685	5785	5886	5986	6087	6187	6287	6388	100
433	6488	6588	6688	6789	6889	6989	7089	7189	7290	7390	100
434	7490	7590	7690	7790	7890	7990	8090	8190	8290	8389	99
435	8489	8589	8689	8789	8888	8988	9088	9188	9287	9387	99
436	9486	9586	9686	9785	9885	9984	640084	640183	640283	640382	99
437	640481	640581	640680	640779	640879	640978	1077	1177	1276	1375	99
438	1474	1573	1672	1771	1871	1970	2069	2168	2267	2366	99
439	2465	2563	2662	2761	2860	2959	3058	3156	3255	3354	99
440	643453	643551	643650	643749	643847	643946	644044	644143	644242	644340	98
441	4439	4537	4636	4734	4832	4931	5029	5127	5226	5324	98
442	5422	5521	5619	5717	5815	5913	6011	6110	6208	6306	98
443	6404	6502	6600	6698	6796	6894	6992	7089	7187	7285	98
444	7383	7481	7579	7676	7774	7872	7969	8067	8165	8262	98
445	8360	8458	8555	8653	8750	8848	8945	9043	9140	9237	97
446	9335	9432	9530	9627	9724	9821	9919	650016	650113	650210	97
447	650308	650405	650502	650599	650696	650793	650890	0987	1084	1181	97
448	1278	1375	1472	1569	1666	1762	1859	1956	2053	2150	97
449	2246	2343	2440	2536	2633	2730	2826	2923	3019	3116	97
450	653213	653309	653405	653502	653598	653695	653791	653888	653984	654080	96
451	4177	4273	4369	4465	4562	4658	4754	4850	4946	5042	96
452	5138	5235	5331	5427	5523	5619	5715	5810	5906	6002	96
453	6098	6194	6290	6386	6482	6577	6673	6769	6864	6960	96
454	7056	7152	7247	7343	7438	7534	7629	7725	7820	7916	96
455	8011	8107	8202	8298	8393	8488	8584	8679	8774	8870	95
456	8965	9060	9155	9250	9346	9441	9536	9631	9726	9821	95
457	9916	660011	660106	660201	660296	660391	660486	660581	660676	660771	95
458	660865	0960	1055	1150	1245	1339	1434	1529	1623	1718	95
459	1813	1907	2002	2096	2191	2286	2380	2475	2569	2663	95
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Logarithms from 1 to 10,000.

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460	662758	662852	662947	663041	663135	663230	663324	663418	663512	663607	94
461	3701	3795	3889	3983	4078	4172	4266	4360	4454	4548	94
462	4642	4736	4830	4924	5018	5112	5206	5299	5393	5487	94
463	5581	5675	5769	5862	5956	6050	6143	6237	6331	6424	94
464	6518	6612	6705	6799	6892	6986	7079	7173	7266	7360	94
465	7453	7546	7640	7733	7826	7920	8013	8106	8199	8293	93
466	8386	8479	8572	8665	8759	8852	8945	9038	9131	9224	93
467	9317	9410	9503	9596	9689	9782	9875	9967	670060	670153	93
468	670246	670339	670431	670524	670617	670710	670802	670895	0988	1080	93
469	1173	1265	1358	1451	1543	1636	1728	1821	1913	2005	93
470	672098	672190	672283	672375	672467	672560	672652	672744	672836	672929	92
471	3021	3113	3205	3297	3390	3482	3574	3666	3758	3850	92
472	3942	4034	4126	4218	4310	4402	4494	4586	4677	4769	92
473	4861	4953	5045	5137	5228	5320	5412	5503	5595	5687	92
474	5778	5870	5962	6053	6145	6236	6328	6419	6511	6602	92
475	6694	6785	6876	6968	7059	7151	7242	7333	7424	7516	91
476	7607	7698	7789	7881	7972	8063	8154	8245	8336	8427	91
477	8518	8609	8700	8791	8882	8973	9064	9155	9246	9337	91
478	9428	9519	9610	9700	9791	9882	9973	680063	680154	680245	91
479	680336	680426	680517	680607	680698	680789	680879	0970	1060	1151	91
480	681241	681332	681422	681513	681603	681693	681784	681874	681964	682055	90
481	2145	2235	2326	2416	2506	2596	2686	2777	2867	2957	90
482	3047	3137	3227	3317	3407	3497	3587	3677	3767	3857	90
483	3947	4037	4127	4217	4307	4396	4486	4576	4666	4756	90
484	4845	4935	5025	5114	5204	5294	5383	5473	5563	5652	90
485	5742	5831	5921	6010	6100	6189	6279	6368	6458	6547	89
486	6636	6726	6815	6904	6994	7083	7172	7261	7351	7440	89
487	7529	7618	7707	7796	7886	7975	8064	8153	8242	8331	89
488	8420	8509	8598	8687	8776	8865	8953	9042	9131	9220	89
489	9309	9398	9486	9575	9664	9753	9841	9930	690019	690107	89
490	690196	690285	690373	690462	690550	690639	690728	690816	690905	690993	89
491	1081	1170	1258	1347	1435	1524	1612	1700	1789	1877	88
492	1965	2053	2142	2230	2318	2406	2494	2583	2671	2759	88
493	2847	2935	3023	3111	3199	3287	3375	3463	3551	3639	88
494	3727	3815	3903	3991	4078	4166	4254	4342	4430	4517	88
495	4605	4693	4781	4868	4956	5044	5131	5219	5307	5394	88
496	5482	5569	5657	5744	5832	5919	6007	6094	6182	6269	87
497	6356	6444	6531	6618	6706	6793	6880	6968	7055	7142	87
498	7229	7317	7404	7491	7578	7665	7752	7839	7926	8014	87
499	8100	8188	8275	8362	8449	8535	8622	8709	8796	8883	87
500	698970	699057	699144	699231	699317	699404	699491	699578	699664	699751	87
501	9838	9924	700011	700098	700184	700271	700358	700444	700531	700617	87
502	700704	700790	0877	0963	1050	1136	1222	1309	1395	1482	86
503	1568	1654	1741	1827	1913	1999	2086	2172	2258	2344	86
504	2431	2517	2603	2689	2775	2861	2947	3033	3119	3205	86
505	3291	3377	3463	3549	3635	3721	3807	3893	3979	4065	86
506	4151	4236	4322	4408	4494	4579	4665	4751	4837	4922	86
507	5008	5094	5179	5265	5350	5436	5522	5607	5693	5778	86
508	5864	5949	6035	6120	6206	6291	6376	6462	6547	6632	85
509	6718	6803	6888	6974	7059	7144	7229	7315	7400	7485	85
510	707570	707655	707740	707826	707911	707996	708081	708166	708251	708336	85
511	8421	8506	8591	8676	8761	8846	8931	9015	9100	9185	85
512	9270	9355	9440	9524	9609	9694	9779	9863	9948	710033	85
513	710117	710202	710287	710371	710456	710540	710625	710710	710794	0879	85
514	0963	1048	1132	1217	1301	1385	1470	1554	1639	1723	84
515	1807	1892	1976	2060	2144	2229	2313	2397	2481	2566	84
516	2650	2734	2818	2902	2986	3070	3154	3238	3323	3407	84
517	3491	3575	3659	3742	3826	3910	3994	4078	4162	4246	84
518	4330	4414	4497	4581	4665	4749	4833	4916	5000	5084	84
519	5167	5251	5335	5418	5502	5586	5669	5753	5836	5920	84
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Logarithms from 1 to 10,000.

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520	716003	716087	716170	716254	716337	716421	716504	716588	716671	716754	83
521	6838	6921	7004	7088	7171	7254	7338	7421	7504	7587	83
522	7671	7754	7837	7920	8003	8086	8169	8253	8336	8419	83
523	8502	8585	8668	8751	8834	8917	9000	9083	9165	9248	83
524	9331	9414	9497	9580	9663	9745	9828	9911	9994	720077	83
525	720159	720242	720325	720407	720490	720573	720655	720738	720821	0903	83
526	0986	1068	1151	1233	1316	1398	1481	1563	1646	1728	82
527	1811	1893	1975	2058	2140	2222	2305	2387	2469	2552	82
528	2634	2716	2798	2881	2963	3045	3127	3209	3291	3374	82
529	3456	3538	3620	3702	3784	3866	3948	4030	4112	4194	82
530	724276	724358	724440	724522	724604	724685	724767	724849	724931	725013	82
531	5095	5176	5258	5340	5422	5503	5585	5667	5748	5830	82
532	5912	5993	6075	6156	6238	6320	6401	6483	6564	6646	82
533	6727	6809	6890	6972	7053	7134	7216	7297	7379	7460	81
534	7541	7623	7704	7785	7866	7948	8029	8110	8191	8273	81
535	8354	8435	8516	8597	8678	8759	8841	8922	9003	9084	81
536	9165	9246	9327	9408	9489	9570	9651	9732	9813	9893	81
537	9974	730055	730136	730217	730298	730378	730459	730540	730621	730702	81
538	730782	0863	0944	1024	1105	1186	1266	1347	1428	1508	81
539	1589	1669	1750	1830	1911	1991	2072	2152	2233	2313	81
540	732394	732474	732555	732635	732715	732796	732876	732956	733037	733117	80
541	3197	3278	3358	3438	3518	3598	3679	3759	3839	3919	80
542	3999	4079	4160	4240	4320	4400	4480	4560	4640	4720	80
543	4800	4880	4960	5040	5120	5199	5279	5359	5439	5519	80
544	5599	5679	5759	5838	5918	5998	6078	6157	6237	6317	80
545	6397	6476	6556	6635	6715	6795	6874	6954	7034	7113	80
546	7193	7272	7352	7431	7511	7590	7670	7749	7829	7908	79
547	7987	8067	8146	8225	8305	8384	8463	8543	8622	8701	79
548	8781	8860	8939	9018	9097	9177	9256	9335	9414	9493	79
549	9572	9651	9731	9810	9889	9968	740047	740126	740205	740284	79
550	740363	740442	740521	740600	740678	740757	740836	740915	740994	741073	79
551	1152	1230	1309	1388	1467	1546	1624	1703	1782	1860	79
552	1939	2018	2096	2175	2254	2332	2411	2489	2568	2647	79
553	2725	2804	2882	2961	3039	3118	3196	3275	3353	3431	78
554	3510	3588	3667	3745	3823	3902	3980	4058	4136	4215	78
555	4293	4371	4449	4528	4606	4684	4762	4840	4919	4997	78
556	5075	5153	5231	5309	5387	5465	5543	5621	5699	5777	78
557	5855	5933	6011	6089	6167	6245	6323	6401	6479	6556	78
558	6634	6712	6790	6868	6945	7023	7101	7179	7256	7334	78
559	7412	7489	7567	7645	7722	7800	7878	7955	8033	8110	78
560	748188	748266	748343	748421	748498	748576	748653	748731	748808	748885	77
561	8963	9040	9118	9195	9272	9350	9427	9504	9582	9659	77
562	9736	9814	9891	9968	750045	750123	750200	750277	750354	750431	77
563	750508	750586	750663	750740	0817	0894	0971	1048	1125	1202	77
564	1279	1356	1433	1510	1587	1664	1741	1818	1895	1972	77
565	2048	2125	2202	2279	2356	2433	2509	2586	2663	2740	77
566	2816	2893	2970	3047	3123	3200	3277	3353	3430	3506	77
567	3583	3660	3736	3813	3889	3966	4042	4119	4195	4272	77
568	4348	4425	4501	4578	4654	4730	4807	4883	4960	5036	76
569	5112	5189	5265	5341	5417	5494	5570	5646	5722	5799	76
570	755875	755951	756027	756103	756180	756256	756332	756408	756484	756560	76
571	6636	6712	6788	6864	6940	7016	7092	7168	7244	7320	76
572	7396	7472	7548	7624	7700	7775	7851	7927	8003	8079	76
573	8155	8230	8306	8382	8458	8533	8609	8685	8761	8836	76
574	8912	8988	9063	9139	9214	9290	9366	9441	9517	9592	76
575	9668	9743	9819	9894	9970	760045	760121	760196	760272	760347	75
576	760422	760498	760573	760649	760724	0799	0875	0950	1025	1101	75
577	1176	1251	1326	1402	1477	1552	1627	1702	1778	1853	75
578	1928	2003	2078	2153	2228	2303	2378	2453	2529	2604	75
579	2679	2754	2829	2904	2978	3053	3128	3203	3278	3353	75
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Logarithms from 1 to 10,000.

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580	763428	763503	763578	763653	763727	763802	763877	763952	764027	764101	75
581	4176	4251	4326	4400	4475	4550	4624	4699	4774	4848	75
582	4923	4998	5072	5147	5221	5296	5370	5445	5520	5594	75
583	5669	5743	5818	5892	5966	6041	6115	6190	6264	6338	74
584	6413	6487	6562	6636	6710	6785	6859	6933	7007	7082	74
585	7156	7230	7304	7379	7453	7527	7601	7675	7749	7823	74
586	7898	7972	8046	8120	8194	8268	8342	8416	8490	8564	74
587	8638	8712	8786	8860	8934	9008	9082	9156	9230	9303	74
588	9377	9451	9525	9599	9673	9746	9820	9894	9968	770042	74
589	770115	770189	770263	770336	770410	770484	770557	770631	770705	0778	74
590	770852	770926	770999	771073	771146	771220	771293	771367	771440	771514	74
591	1587	1661	1734	1808	1881	1955	2028	2102	2175	2248	73
592	2322	2395	2468	2542	2615	2688	2762	2835	2908	2981	73
593	3055	3128	3201	3274	3348	3421	3494	3567	3640	3713	73
594	3786	3860	3933	4006	4079	4152	4225	4298	4371	4444	73
595	4517	4590	4663	4736	4809	4882	4955	5028	5100	5173	73
596	5246	5319	5392	5465	5538	5610	5683	5756	5829	5902	73
597	5974	6047	6120	6193	6265	6338	6411	6483	6556	6629	73
598	6701	6774	6846	6919	6992	7064	7137	7209	7282	7354	73
599	7427	7499	7572	7644	7717	7789	7862	7934	8006	8079	72
600	778151	778224	778296	778368	778441	778513	778585	778658	778730	778802	72
601	8874	8947	9019	9091	9163	9236	9308	9380	9452	9524	72
602	9596	9669	9741	9813	9885	9957	780029	780101	780173	780245	72
603	780317	780389	780461	780533	780605	780677	0749	0821	0893	0965	72
604	1037	1109	1181	1253	1324	1396	1468	1540	1612	1684	72
605	1755	1827	1899	1971	2042	2114	2186	2258	2329	2401	72
606	2473	2544	2616	2688	2759	2831	2902	2974	3046	3117	72
607	3189	3260	3332	3403	3475	3546	3618	3689	3761	3832	71
608	3904	3975	4046	4118	4189	4261	4332	4403	4475	4546	71
609	4617	4689	4760	4831	4902	4974	5045	5116	5187	5259	71
610	785330	785401	785472	785543	785615	785686	785757	785828	785899	785970	71
611	6041	6112	6183	6254	6325	6396	6467	6538	6609	6680	71
612	6751	6822	6893	6964	7035	7106	7177	7248	7319	7390	71
613	7460	7531	7602	7673	7744	7815	7885	7956	8027	8098	71
614	8168	8239	8310	8381	8451	8522	8593	8663	8734	8804	71
615	8875	8946	9016	9087	9157	9228	9299	9369	9440	9510	71
616	9581	9651	9722	9792	9863	9933	790004	790074	790144	790215	70
617	790285	790356	790426	790496	790567	790637	0707	0778	0848	0918	70
618	0988	1059	1129	1199	1269	1340	1410	1480	1550	1620	70
619	1691	1761	1831	1901	1971	2041	2111	2181	2252	2322	70
620	792392	792462	792532	792602	792672	792742	792812	792882	792952	793022	70
621	3092	3162	3231	3301	3371	3441	3511	3581	3651	3721	70
622	3790	3860	3930	4000	4070	4139	4209	4279	4349	4418	70
623	4488	4558	4627	4697	4767	4836	4906	4976	5045	5115	70
624	5185	5254	5324	5393	5463	5532	5602	5672	5741	5811	70
625	5880	5949	6019	6088	6158	6227	6297	6366	6436	6505	69
626	6574	6644	6713	6782	6852	6921	6990	7060	7129	7198	69
627	7268	7337	7406	7475	7545	7614	7683	7752	7821	7890	69
628	7960	8029	8098	8167	8236	8305	8374	8443	8513	8582	69
629	8651	8720	8789	8858	8927	8996	9065	9134	9203	9272	69
630	799341	799409	799478	799547	799616	799685	799754	799823	799892	799961	69
631	800029	800098	800167	800236	800305	800373	800442	800511	800580	800648	69
632	0717	0786	0854	0923	0992	1061	1129	1198	1266	1335	69
633	1404	1472	1541	1609	1678	1747	1815	1884	1952	2021	69
634	2089	2158	2226	2295	2363	2432	2500	2568	2637	2705	69
635	2774	2842	2910	2979	3047	3116	3184	3252	3321	3389	68
636	3457	3525	3594	3662	3730	3798	3867	3935	4003	4071	68
637	4139	4208	4276	4344	4412	4480	4548	4616	4685	4753	68
638	4821	4889	4957	5025	5093	5161	5229	5297	5365	5433	68
639	5501	5569	5637	5705	5773	5841	5908	5976	6044	6112	68
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Logarithms from 1 to 10,000.

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640	806180	806248	806316	806384	806451	806519	806587	806655	806723	806790	68
641	6858	6926	6994	7061	7129	7197	7264	7332	7400	7467	68
642	7535	7603	7670	7738	7806	7873	7941	8008	8076	8143	68
643	8211	8279	8346	8414	8481	8549	8616	8684	8751	8818	67
644	8886	8953	9021	9088	9156	9223	9290	9358	9425	9492	67
645	9560	9627	9694	9762	9829	9896	9964	810031	810098	810165	67
646	810233	810300	810367	810434	810501	810569	810636	0703	0770	0837	67
647	0904	0971	1039	1106	1173	1240	1307	1374	1441	1508	67
648	1575	1642	1709	1776	1843	1910	1977	2044	2111	2178	67
649	2245	2312	2379	2445	2512	2579	2646	2713	2780	2847	67
650	812913	812980	813047	813114	813181	813247	813314	813381	813448	813514	67
651	3581	3648	3714	3781	3848	3914	3981	4048	4114	4181	67
652	4248	4314	4381	4447	4514	4581	4647	4714	4780	4847	67
653	4913	4980	5046	5113	5179	5246	5312	5378	5445	5511	66
654	5578	5644	5711	5777	5843	5910	5976	6042	6109	6175	66
655	6241	6308	6374	6440	6506	6573	6639	6705	6771	6838	66
656	6904	6970	7036	7102	7169	7235	7301	7367	7433	7499	66
657	7565	7631	7698	7764	7830	7896	7962	8028	8094	8160	66
658	8226	8292	8358	8424	8490	8556	8622	8688	8754	8820	66
659	8885	8951	9017	9083	9149	9215	9281	9346	9412	9478	66
660	819544	819610	819676	819741	819807	819873	819939	820004	820070	820136	66
661	820201	820267	820333	820399	820464	820530	820595	0661	0727	0792	66
662	0858	0924	0989	1055	1120	1186	1251	1317	1382	1448	66
663	1514	1579	1645	1710	1775	1841	1906	1972	2037	2103	65
664	2168	2233	2299	2364	2430	2495	2560	2626	2691	2756	65
665	2822	2887	2952	3018	3083	3148	3213	3279	3344	3409	65
666	3474	3539	3605	3670	3735	3800	3865	3930	3996	4061	65
667	4126	4191	4256	4321	4386	4451	4516	4581	4646	4711	65
668	4776	4841	4906	4971	5036	5101	5166	5231	5296	5361	65
669	5426	5491	5556	5621	5686	5751	5815	5880	5945	6010	65
670	826075	826140	826204	826269	826334	826399	826464	826528	826593	826658	65
671	6723	6787	6852	6917	6981	7046	7111	7175	7240	7305	65
672	7369	7434	7499	7563	7628	7692	7757	7821	7886	7951	65
673	8015	8080	8144	8209	8273	8338	8402	8467	8531	8595	64
674	8660	8724	8789	8853	8918	8982	9046	9111	9175	9239	64
675	9304	9368	9432	9497	9561	9625	9690	9754	9818	9882	64
676	9947	830011	830075	830139	830204	830268	830332	830396	830460	830525	64
677	830589	0653	0717	0781	0845	0909	0973	1037	1102	1166	64
678	1230	1294	1358	1422	1486	1550	1614	1678	1742	1806	64
679	1870	1934	1998	2062	2126	2189	2253	2317	2381	2445	64
680	832509	832573	832637	832700	832764	832828	832892	832956	833020	833083	64
681	3147	3211	3275	3338	3402	3466	3530	3593	3657	3721	64
682	3784	3848	3912	3975	4039	4103	4166	4230	4294	4357	64
683	4421	4484	4548	4611	4675	4739	4802	4866	4929	4993	64
684	5056	5120	5183	5247	5310	5373	5437	5500	5564	5627	63
685	5691	5754	5817	5881	5944	6007	6071	6134	6197	6261	63
686	6324	6387	6451	6514	6577	6641	6704	6767	6830	6894	63
687	6957	7020	7083	7146	7210	7273	7336	7399	7462	7525	63
688	7588	7652	7715	7778	7841	7904	7967	8030	8093	8156	63
689	8219	8282	8345	8408	8471	8534	8597	8660	8723	8786	63
690	838849	838912	838975	839038	839101	839164	839227	839289	839352	839415	63
691	9478	9541	9604	9667	9729	9792	9855	9918	9981	840043	63
692	840106	840169	840232	840294	840357	840420	840482	840545	840608	0671	63
693	0733	0796	0859	0921	0984	1046	1109	1172	1234	1297	63
694	1359	1422	1485	1547	1610	1672	1735	1797	1860	1922	63
695	1985	2047	2110	2172	2235	2297	2360	2422	2484	2547	62
696	2609	2672	2734	2796	2859	2921	2983	3046	3108	3170	62
697	3233	3295	3357	3420	3482	3544	3606	3669	3731	3793	62
698	3855	3918	3980	4042	4104	4166	4229	4291	4353	4415	62
699	4477	4539	4601	4664	4726	4788	4850	4912	4974	5036	62
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Logarithms from 1 to 10,000.

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700	845098	845160	845222	845284	845346	845408	845470	845532	845594	845656	62
701	5718	5780	5842	5904	5966	6028	6090	6151	6213	6275	62
702	6337	6399	6461	6523	6585	6646	6708	6770	6832	6894	62
703	6955	7017	7079	7141	7202	7264	7326	7388	7449	7511	62
704	7573	7634	7696	7758	7819	7881	7943	8004	8066	8128	62
705	8189	8251	8312	8374	8435	8497	8559	8620	8682	8743	62
706	8805	8866	8928	8989	9051	9112	9174	9235	9297	9358	61
707	9419	9481	9542	9604	9665	9726	9788	9849	9911	9972	61
708	850033	850095	850156	850217	850279	850340	850401	850462	850524	850585	61
709	0646	0707	0769	0830	0891	0952	1014	1075	1136	1197	61
710	851258	851320	851381	851442	851503	851564	851625	851686	851747	851809	61
711	1870	1931	1992	2053	2114	2175	2236	2297	2358	2419	61
712	2480	2541	2602	2663	2724	2785	2846	2907	2968	3029	61
713	3090	3150	3211	3272	3333	3394	3455	3516	3577	3637	61
714	3698	3759	3820	3881	3941	4002	4063	4124	4185	4245	61
715	4306	4367	4428	4488	4549	4610	4670	4731	4792	4852	61
716	4913	4974	5034	5095	5156	5216	5277	5337	5398	5459	61
717	5519	5580	5640	5701	5761	5822	5882	5943	6003	6064	61
718	6124	6185	6245	6306	6366	6427	6487	6548	6608	6668	60
719	6729	6789	6850	6910	6970	7031	7091	7152	7212	7272	60
720	857332	857393	857453	857513	857574	857634	857694	857755	857815	857875	60
721	7935	7995	8056	8116	8176	8236	8297	8357	8417	8477	60
722	8537	8597	8657	8718	8778	8838	8898	8958	9018	9078	60
723	9138	9198	9258	9318	9379	9439	9499	9559	9619	9679	60
724	9739	9799	9859	9918	9978	860038	860098	860158	860218	860278	60
725	860338	860398	860458	860518	860578	0637	0697	0757	0817	0877	60
726	0937	0996	1056	1116	1176	1236	1295	1355	1415	1475	60
727	1534	1594	1654	1714	1773	1833	1893	1952	2012	2072	60
728	2131	2191	2251	2310	2370	2430	2489	2549	2608	2668	60
729	2728	2787	2847	2906	2966	3025	3085	3144	3204	3263	60
730	863323	863382	863442	863501	863561	863620	863680	863739	863799	863858	59
731	3917	3977	4036	4096	4155	4214	4274	4333	4392	4452	59
732	4511	4570	4630	4689	4748	4808	4867	4926	4985	5045	59
733	5104	5163	5222	5282	5341	5400	5459	5519	5578	5637	59
734	5696	5755	5814	5874	5933	5992	6051	6110	6169	6228	59
735	6287	6346	6405	6465	6524	6583	6642	6701	6760	6819	59
736	6878	6937	6996	7055	7114	7173	7232	7291	7350	7409	59
737	7467	7526	7585	7644	7703	7762	7821	7880	7939	7998	59
738	8056	8115	8174	8233	8292	8350	8409	8468	8527	8586	59
739	8644	8703	8762	8821	8879	8938	8997	9056	9114	9173	59
740	869232	869290	869349	869408	869466	869525	869584	869642	869701	869760	59
741	9818	9877	9935	9994	870053	870111	870170	870228	870287	870345	59
742	870404	870462	870521	870579	0638	0696	0755	0813	0872	0930	58
743	0989	1047	1106	1164	1223	1281	1339	1398	1456	1515	58
744	1573	1631	1690	1748	1806	1865	1923	1981	2040	2098	58
745	2156	2215	2273	2331	2389	2448	2506	2564	2622	2681	58
746	2739	2797	2855	2913	2972	3030	3088	3146	3204	3262	58
747	3321	3379	3437	3495	3553	3611	3669	3727	3785	3844	58
748	3902	3960	4018	4076	4134	4192	4250	4308	4366	4424	58
749	4482	4540	4598	4656	4714	4772	4830	4888	4945	5003	58
750	875061	875119	875177	875235	875293	875351	875409	875466	875524	875582	58
751	5640	5698	5756	5813	5871	5929	5987	6045	6102	6160	58
752	6218	6276	6333	6391	6449	6507	6564	6622	6680	6737	58
753	6795	6853	6910	6968	7026	7083	7141	7199	7256	7314	58
754	7371	7429	7487	7544	7602	7659	7717	7774	7832	7889	58
755	7947	8004	8062	8119	8177	8234	8292	8349	8407	8464	57
756	8522	8579	8637	8694	8752	8809	8866	8924	8981	9039	57
757	9096	9153	9211	9268	9325	9383	9440	9497	9555	9612	57
758	9669	9726	9784	9841	9898	9956	880013	880070	880127	880185	57
759	880242	880299	880356	880413	880471	880528	0585	0642	0699	0756	57
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Logarithms from 1 to 10,000.

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760	880814	880871	880928	880985	881042	881099	881156	881213	881271	881328	57
761	1385	1442	1499	1556	1613	1670	1727	1784	1841	1898	57
762	1955	2012	2069	2126	2183	2240	2297	2354	2411	2468	57
763	2525	2581	2638	2695	2752	2809	2866	2923	2980	3037	57
764	3093	3150	3207	3264	3321	3377	3434	3491	3548	3605	57
765	3661	3718	3775	3832	3888	3945	4002	4059	4115	4172	57
766	4229	4285	4342	4399	4455	4512	4569	4625	4682	4739	57
767	4795	4852	4909	4965	5022	5078	5135	5192	5248	5305	57
768	5361	5418	5474	5531	5587	5644	5700	5757	5813	5870	57
769	5926	5983	6039	6096	6152	6209	6265	6321	6378	6434	56
770	886491	886547	886604	886660	886716	886773	886829	886885	886942	886998	56
771	7054	7111	7167	7223	7280	7336	7392	7449	7505	7561	56
772	7617	7674	7730	7786	7842	7898	7955	8011	8067	8123	56
773	8179	8236	8292	8348	8404	8460	8516	8573	8629	8685	56
774	8741	8797	8853	8909	8965	9021	9077	9134	9190	9246	56
775	9302	9358	9414	9470	9526	9582	9638	9694	9750	9806	56
776	9862	9918	9974	890030	890086	890141	890197	890253	890309	890365	56
777	890421	890477	890533	0589	0645	0700	0756	0812	0868	0924	56
778	0980	1035	1091	1147	1203	1259	1314	1370	1426	1482	56
779	1537	1593	1649	1705	1760	1816	1872	1928	1983	2039	56
780	892095	892150	892206	892262	892317	892373	892429	892484	892540	892595	56
781	2651	2707	2762	2818	2873	2929	2985	3040	3096	3151	56
782	3207	3262	3318	3373	3429	3484	3540	3595	3651	3706	56
783	3762	3817	3873	3928	3984	4039	4094	4150	4205	4261	55
784	4316	4371	4427	4482	4538	4593	4648	4704	4759	4814	55
785	4870	4925	4980	5036	5091	5146	5201	5257	5312	5367	55
786	5423	5478	5533	5588	5644	5699	5754	5809	5864	5920	55
787	5975	6030	6085	6140	6195	6251	6306	6361	6416	6471	55
788	6526	6581	6636	6692	6747	6802	6857	6912	6967	7022	55
789	7077	7132	7187	7242	7297	7352	7407	7462	7517	7572	55
790	897627	897682	897737	897792	897847	897902	897957	898012	898067	898122	55
791	8176	8231	8286	8341	8396	8451	8506	8561	8615	8670	55
792	8725	8780	8835	8890	8944	8999	9054	9109	9164	9218	55
793	9273	9328	9383	9437	9492	9547	9602	9656	9711	9766	55
794	9821	9875	9930	9985	900039	900094	900149	900203	900258	900312	55
795	900367	900422	900476	900531	0586	0640	0695	0749	0804	0859	55
796	0913	0968	1022	1077	1131	1186	1240	1295	1349	1404	55
797	1458	1513	1567	1622	1676	1731	1785	1840	1894	1948	54
798	2003	2057	2112	2166	2221	2275	2329	2384	2438	2492	54
799	2547	2601	2655	2710	2764	2818	2873	2927	2981	3036	54
800	903090	903144	903199	903253	903307	903361	903416	903470	903524	903578	54
801	3633	3687	3741	3795	3849	3904	3958	4012	4066	4120	54
802	4174	4229	4283	4337	4391	4445	4499	4553	4607	4661	54
803	4716	4770	4824	4878	4932	4986	5040	5094	5148	5202	54
804	5256	5310	5364	5418	5472	5526	5580	5634	5688	5742	54
805	5796	5850	5904	5958	6012	6066	6119	6173	6227	6281	54
806	6335	6389	6443	6497	6551	6604	6658	6712	6766	6820	54
807	6874	6927	6981	7035	7089	7143	7196	7250	7304	7358	54
808	7411	7465	7519	7573	7626	7680	7734	7787	7841	7895	54
809	7949	8002	8056	8109	8163	8217	8270	8324	8378	8431	54
810	908485	908539	908592	908646	908699	908753	908807	908860	908914	908967	54
811	9021	9074	9128	9181	9235	9289	9342	9396	9449	9503	54
812	9556	9609	9663	9716	9770	9823	9877	9930	9984	910037	53
813	910091	910144	910197	910251	910304	910358	910411	910464	910518	0571	53
814	0624	0678	0731	0784	0838	0891	0944	0998	1051	1104	53
815	1158	1211	1264	1317	1371	1424	1477	1530	1584	1637	53
816	1690	1743	1797	1850	1903	1956	2009	2063	2116	2169	53
817	2222	2275	2328	2381	2435	2488	2541	2594	2647	2700	53
818	2753	2806	2859	2913	2966	3019	3072	3125	3178	3231	53
819	3284	3337	3390	3443	3496	3549	3602	3655	3708	3761	53
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Logarithms from 1 to 10,000.

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820	913814	913867	913920	913973	914026	914079	914132	914184	914237	914290	53
821	4343	4396	4449	4502	4555	4608	4660	4713	4766	4819	53
822	4872	4925	4977	5030	5083	5136	5189	5241	5294	5347	53
823	5400	5453	5505	5558	5611	5664	5716	5769	5822	5875	53
824	5927	5980	6033	6085	6138	6191	6243	6296	6349	6401	53
825	6454	6507	6559	6612	6664	6717	6770	6822	6875	6927	53
826	6980	7033	7085	7138	7190	7243	7295	7348	7400	7453	53
827	7506	7558	7611	7663	7716	7768	7820	7873	7925	7978	52
828	8030	8083	8135	8188	8240	8293	8345	8397	8450	8502	52
829	8555	8607	8659	8712	8764	8816	8869	8921	8973	9026	52
830	919078	919130	919183	919235	919287	919340	919392	919444	919496	919549	52
831	9601	9653	9706	9758	9810	9862	9914	9967	920019	920071	52
832	920123	920176	920228	920280	920332	920384	920436	920489	0541	0593	52
833	0645	0697	0749	0801	0853	0906	0958	1010	1062	1114	52
834	1166	1218	1270	1322	1374	1426	1478	1530	1582	1634	52
835	1686	1738	1790	1842	1894	1946	1998	2050	2102	2154	52
836	2206	2258	2310	2362	2414	2466	2518	2570	2622	2674	52
837	2725	2777	2829	2881	2933	2985	3037	3089	3140	3192	52
838	3244	3296	3348	3399	3451	3503	3555	3607	3658	3710	52
839	3762	3814	3865	3917	3969	4021	4072	4124	4176	4228	52
840	924279	924331	924383	924434	924486	924538	924589	924641	924693	924744	52
841	4796	4848	4899	4951	5003	5054	5106	5157	5209	5261	52
842	5312	5364	5415	5467	5518	5570	5621	5673	5725	5776	52
843	5828	5879	5931	5982	6034	6085	6137	6188	6239	6291	51
844	6342	6394	6445	6497	6548	6600	6651	6702	6754	6805	51
845	6857	6908	6959	7011	7062	7114	7165	7216	7268	7319	51
846	7370	7422	7473	7524	7576	7627	7678	7730	7781	7832	51
847	7883	7935	7986	8037	8088	8140	8191	8242	8293	8345	51
848	8396	8447	8498	8549	8601	8652	8703	8754	8805	8857	51
849	8908	8959	9010	9061	9112	9163	9215	9266	9317	9368	51
850	929419	929470	929521	929572	929623	929674	929725	929776	929827	929879	51
851	9930	9981	930032	930083	930134	930185	930236	930287	930338	930389	51
852	930440	930491	0542	0592	0643	0694	0745	0796	0847	0898	51
853	0949	1000	1051	1102	1153	1203	1254	1305	1356	1407	51
854	1458	1509	1560	1610	1661	1712	1763	1814	1864	1915	51
855	1966	2017	2068	2118	2169	2220	2271	2322	2372	2423	51
856	2474	2524	2575	2626	2677	2727	2778	2829	2879	2930	51
857	2981	3031	3082	3133	3183	3234	3285	3335	3386	3437	51
858	3487	3538	3589	3639	3690	3740	3791	3841	3892	3943	51
859	3993	4044	4094	4145	4195	4246	4296	4347	4397	4448	51
860	934498	934549	934599	934650	934700	934751	934801	934852	934902	934953	50
861	5003	5054	5104	5154	5205	5255	5306	5356	5406	5457	50
862	5507	5558	5608	5658	5709	5759	5809	5860	5910	5960	50
863	6011	6061	6111	6162	6212	6262	6313	6363	6413	6463	50
864	6514	6564	6614	6665	6715	6765	6815	6865	6916	6966	50
865	7016	7066	7116	7167	7217	7267	7317	7367	7418	7468	50
866	7518	7568	7618	7668	7718	7769	7819	7869	7919	7969	50
867	8019	8069	8119	8169	8219	8269	8319	8370	8420	8470	50
868	8520	8570	8620	8670	8720	8770	8820	8870	8920	8970	50
869	9020	9070	9120	9170	9220	9270	9319	9369	9419	9469	50
870	939519	939569	939619	939669	939719	939769	939819	939869	939918	939968	50
871	940018	940068	940118	940168	940218	940267	940317	940367	940417	940467	50
872	0516	0566	0616	0666	0716	0765	0815	0865	0915	0964	50
873	1014	1064	1114	1163	1213	1263	1313	1362	1412	1462	50
874	1511	1561	1611	1660	1710	1760	1809	1859	1909	1958	50
875	2008	2058	2107	2157	2207	2256	2306	2355	2405	2455	50
876	2504	2554	2603	2653	2702	2752	2801	2851	2901	2950	50
877	3000	3049	3099	3148	3198	3247	3297	3346	3396	3445	49
878	3495	3544	3593	3643	3692	3742	3791	3841	3890	3939	49
879	3989	4038	4088	4137	4186	4236	4285	4335	4384	4433	49
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Logarithms from 1 to 10,000

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880	944483	944532	944581	944631	944680	944729	944779	944828	944877	944927	49
881	4976	5025	5074	5124	5173	5222	5272	5321	5370	5419	49
882	5469	5518	5567	5616	5665	5715	5764	5813	5862	5912	49
883	5961	6010	6059	6108	6157	6207	6256	6305	6354	6403	49
884	6452	6501	6551	6600	6649	6698	6747	6796	6845	6894	49
885	6943	6992	7041	7090	7139	7189	7238	7287	7336	7385	49
886	7434	7483	7532	7581	7630	7679	7728	7777	7826	7875	49
887	7924	7973	8022	8070	8119	8168	8217	8266	8315	8364	49
888	8413	8462	8511	8560	8608	8657	8706	8755	8804	8853	49
889	8902	8951	8999	9048	9097	9146	9195	9244	9292	9341	49
890	949390	949439	949488	949536	949585	949634	949683	949731	949780	949829	49
891	9878	9926	9975	950024	950073	950121	950170	950219	950267	950316	49
892	950365	950414	950462	0511	0560	0608	0657	0706	0754	0803	49
893	0851	0900	0949	0997	1046	1095	1143	1192	1240	1289	49
894	1338	1386	1435	1483	1532	1580	1629	1677	1726	1775	49
895	1823	1872	1920	1969	2017	2066	2114	2163	2211	2259	48
896	2308	2356	2405	2453	2502	2550	2599	2647	2696	2744	48
897	2792	2841	2889	2938	2986	3034	3083	3131	3180	3228	48
898	3276	3325	3373	3421	3470	3518	3566	3615	3663	3711	48
899	3760	3808	3856	3905	3953	4001	4049	4098	4146	4194	48
900	954243	954291	954339	954387	954435	954484	954532	954580	954628	954677	48
901	4725	4773	4821	4869	4918	4966	5014	5062	5110	5158	48
902	5207	5255	5303	5352	5399	5447	5495	5543	5592	5640	48
903	5688	5736	5784	5832	5880	5928	5976	6024	6072	6120	48
904	6168	6216	6265	6313	6361	6409	6457	6505	6553	6601	48
905	6649	6697	6745	6793	6840	6888	6936	6984	7032	7080	48
906	7128	7176	7224	7272	7320	7368	7416	7464	7512	7559	48
907	7607	7655	7703	7751	7799	7847	7894	7942	7990	8038	48
908	8086	8134	8181	8229	8277	8325	8373	8421	8468	8516	48
909	8564	8612	8659	8707	8755	8803	8850	8898	8946	8994	48
910	959041	959089	959137	959185	959232	959280	959328	959375	959423	959471	48
911	9518	9566	9614	9661	9709	9757	9804	9852	9900	9947	48
912	9995	960042	960090	960138	960185	960233	960281	960328	960376	960423	48
913	960471	0518	0566	0613	0661	0709	0756	0804	0851	0899	48
914	0946	0994	1041	1089	1136	1184	1231	1279	1326	1374	47
915	1421	1469	1516	1563	1611	1658	1706	1753	1801	1848	47
916	1895	1943	1990	2038	2085	2132	2180	2227	2275	2322	47
917	2369	2417	2464	2511	2559	2606	2653	2701	2748	2795	47
918	2843	2890	2937	2985	3032	3079	3126	3174	3221	3268	47
919	3316	3363	3410	3457	3504	3552	3599	3646	3693	3741	47
920	963788	963835	963882	963929	963977	964024	964071	964118	964165	964212	47
921	4260	4307	4354	4401	4448	4495	4542	4590	4637	4684	47
922	4731	4778	4825	4872	4919	4966	5013	5060	5108	5155	47
923	5202	5249	5296	5343	5390	5437	5484	5531	5578	5625	47
924	5672	5719	5766	5813	5860	5907	5954	6001	6048	6095	47
925	6142	6189	6236	6283	6329	6376	6423	6470	6517	6564	47
926	6611	6658	6705	6752	6799	6845	6892	6939	6986	7033	47
927	7080	7127	7173	7220	7267	7314	7361	7408	7454	7501	47
928	7548	7595	7642	7688	7735	7782	7829	7875	7922	7969	47
929	8016	8062	8109	8156	8203	8249	8296	8343	8389	8436	47
930	968483	968530	968576	968623	968670	968716	968763	968810	968856	968903	47
931	8950	8996	9043	9090	9136	9183	9229	9276	9323	9369	47
932	9416	9463	9509	9556	9602	9649	9695	9742	9789	9835	47
933	9882	9928	9975	970021	970068	970114	970161	970207	970254	970300	47
934	970347	970393	970440	0486	0533	0579	0626	0672	0719	0765	46
935	0812	0858	0904	0951	0997	1044	1090	1137	1183	1229	46
936	1276	1322	1369	1415	1461	1508	1554	1601	1647	1693	46
937	1740	1786	1832	1879	1925	1971	2018	2064	2110	2157	46
938	2203	2249	2295	2342	2388	2434	2481	2527	2573	2619	46
939	2666	2712	2758	2804	2851	2897	2943	2989	3035	3082	46
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Logarithms from 1 to 10,000.

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940	973128	973174	973220	973266	973313	973359	973405	973451	973497	973543	46
941	3590	3636	3682	3728	3774	3820	3866	3913	3959	4005	46
942	4051	4097	4143	4189	4235	4281	4327	4374	4420	4466	46
943	4512	4558	4604	4650	4696	4742	4788	4834	4880	4926	46
944	4972	5018	5064	5110	5156	5202	5248	5294	5340	5386	46
945	5432	5478	5524	5570	5616	5662	5707	5753	5799	5845	46
946	5891	5937	5933	6029	6075	6121	6167	6212	6258	6304	46
947	6350	6396	6442	6488	6533	6579	6625	6671	6717	6763	46
948	6808	6854	6900	6946	6992	7037	7083	7129	7175	7220	46
949	7266	7312	7358	7403	7449	7495	7541	7586	7632	7678	46
950	977724	977769	977815	977861	977906	977952	977998	978043	978089	978135	46
951	8181	8226	8272	8317	8363	8409	8454	8500	8546	8591	46
952	8637	8683	8728	8774	8819	8865	8911	8956	9002	9047	46
953	9093	9138	9184	9230	9275	9321	9366	9412	9457	9503	46
954	9548	9594	9639	9685	9730	9776	9821	9867	9912	9958	46
955	980003	980049	980094	980140	980185	980231	980276	980322	980367	980412	45
956	0458	0503	0549	0594	0640	0685	0730	0776	0821	0867	45
957	0912	0957	1003	1048	1093	1139	1184	1229	1275	1320	45
958	1366	1411	1456	1501	1547	1592	1637	1683	1728	1773	45
959	1819	1864	1909	1954	2000	2045	2090	2135	2181	2226	45
960	982271	982316	982362	982407	982452	982497	982543	982588	982633	982678	45
961	2723	2769	2814	2859	2904	2949	2994	3040	3085	3130	45
962	3175	3220	3265	3310	3356	3401	3446	3491	3536	3581	45
963	3626	3671	3716	3762	3807	3852	3897	3942	3987	4032	45
964	4077	4122	4167	4212	4257	4302	4347	4392	4437	4482	45
965	4527	4572	4617	4662	4707	4752	4797	4842	4887	4932	45
966	4977	5022	5067	5112	5157	5202	5247	5292	5337	5382	45
967	5426	5471	5516	5561	5606	5651	5696	5741	5786	5830	45
968	5875	5920	5965	6010	6055	6100	6144	6189	6234	6279	45
969	6324	6369	6413	6458	6503	6548	6593	6637	6682	6727	45
970	986772	986817	986861	986906	986951	986996	987040	987085	987130	987175	45
971	7219	7264	7309	7353	7398	7443	7488	7532	7577	7622	45
972	7666	7711	7756	7800	7845	7890	7934	7979	8024	8068	45
973	8113	8157	8202	8247	8291	8336	8381	8425	8470	8514	45
974	8559	8604	8648	8693	8737	8782	8826	8871	8916	8960	45
975	9005	9049	9094	9138	9183	9227	9272	9316	9361	9405	45
976	9450	9494	9539	9583	9628	9672	9717	9761	9806	9850	44
977	9895	9939	9983	990028	990072	990117	990161	990206	990250	990294	44
978	990339	990383	990428	0472	0516	0561	0605	0650	0694	0738	44
979	0783	0827	0871	0916	0960	1004	1049	1093	1137	1182	44
980	991226	991270	991315	991359	991403	991448	991492	991536	991580	991625	44
981	1669	1713	1758	1802	1846	1890	1935	1979	2023	2067	44
982	2111	2156	2200	2244	2288	2333	2377	2421	2465	2509	44
983	2554	2598	2642	2686	2730	2774	2819	2863	2907	2951	44
984	2995	3039	3083	3127	3172	3216	3260	3304	3348	3392	44
985	3436	3480	3524	3568	3613	3657	3701	3745	3789	3833	44
986	3877	3921	3965	4009	4053	4097	4141	4185	4229	4273	44
987	4317	4361	4405	4449	4493	4537	4581	4625	4669	4713	44
988	4757	4801	4845	4889	4933	4977	5021	5065	5108	5152	44
989	5196	5240	5284	5328	5372	5416	5460	5504	5547	5591	44
990	995635	995679	995723	995767	995811	995854	995898	995942	995986	996030	44
991	6074	6117	6161	6205	6249	6293	6337	6380	6424	6468	44
992	6512	6555	6599	6643	6687	6731	6774	6818	6862	6906	44
993	6949	6993	7037	7080	7124	7168	7212	7255	7299	7343	44
994	7386	7430	7474	7517	7561	7605	7648	7692	7736	7779	44
995	7823	7867	7910	7954	7998	8041	8085	8129	8172	8216	44
996	8259	8303	8347	8390	8434	8477	8521	8564	8608	8652	44
997	8695	8739	8782	8826	8869	8913	8956	9000	9043	9087	44
998	9130	9174	9218	9261	9305	9348	9392	9435	9479	9522	44
999	9565	9609	9652	9696	9739	9783	9826	9870	9913	9957	43
N.	0	1	2	3	4	5	6	7	8	9	D.

Min.	2 Hours.	Diff. 100 sec.	3 Hours.	Diff. 100 sec.	4 Hours.	Diff. 100 sec.	5 Hours.	Diff. 100 sec.	6 Hours.	Diff. 100 sec.	Min.
0	8·825992	11737	9·165679	7602	9·397940	5457	9·568894	4107	9·698970	3152	60
1	·833034	11635	·170240	7555	·401214	5428	·571358	4088	·700861	3138	59
2	·840015	11535	·174773	7509	·404471	5401	·573811	4070	·702743	3124	58
3	·846936	11437	·179278	7463	·407713	5375	·576253	4052	·704618	3110	57
4	·853798	11340	·183756	7418	·410938	5348	·578684	4033	·706484	3097	56
5	·860602	11245	·188207	7373	·414147	5322	·581104	4015	·708342	3083	55
6	·867349	11152	·192631	7329	·417340	5296	·583513	3997	·710192	3070	54
7	·874040	11061	·197028	7285	·420517	5270	·585911	3980	·712034	3057	53
8	·880676	10970	·201399	7241	·423679	5243	·588299	3962	·713868	3043	52
9	·887258	10880	·205745	7198	·426825	5217	·590676	3944	·715694	3030	51
10	8·893785	10792	9·210064	7156	9·429955	5192	9·593042	3927	9·717512	3017	50
11	8·900261	10706	9·214358	7114	9·433070	5167	9·595398	3910	9·719322	3005	49
12	·906684	10620	·218627	7073	·436170	5142	·597744	3892	·721124	2992	48
13	·913055	10536	·222870	7032	·439255	5117	·600078	3875	·722919	2978	47
14	·919377	10453	·227089	6991	·442325	5092	·602403	3857	·724705	2965	46
15	·925648	10371	·231284	6950	·445379	5067	·604717	3840	·726484	2951	45
16	·931871	10290	·235454	6910	·448419	5043	·607021	3823	·728255	2939	44
17	·938045	10210	·239600	6870	·451445	5018	·609315	3806	·730018	2926	43
18	·944171	10132	·243722	6831	·454455	4993	·611598	3790	·731774	2913	42
19	·950251	10055	·247821	6792	·457451	4969	·613872	3772	·733522	2900	41
20	8·956284	9979	9·251897	6753	9·460433	4945	9·616135	3756	9·735262	2887	40
21	8·962271	9904	9·255949	6715	9·463400	4921	9·618388	3740	9·736994	2875	39
22	·968213	9830	·259978	6678	·466354	4898	·620632	3723	·738719	2863	38
23	·974111	9757	·263985	6640	·469293	4875	·622865	3707	·740437	2850	37
24	·979965	9684	·267969	6602	·472218	4852	·625089	3690	·742147	2837	36
25	·985775	9612	·271930	6566	·475129	4828	·627303	3674	·743849	2825	35
26	·991543	9543	·275870	6530	·478026	4805	·629507	3658	·745544	2813	34
27	8·997269	9474	·279788	6493	·480909	4782	·631701	3642	·747232	2800	33
28	9·002953	9405	·283684	6457	·483779	4760	·633886	3626	·748912	2788	32
29	·008596	9338	·287558	6422	·486635	4738	·636061	3610	·750585	2776	31
30	9·014198	9272	9·291412	6387	9·489478	4715	9·638227	3593	9·75225	2763	30
31	9·019761	9206	9·295244	6352	9·492307	4693	9·640383	3577	9·75390	2750	29
32	·025284	9141	·299055	6317	·495123	4672	·642529	3562	·75550	2738	28
33	·030768	9077	·302845	6283	·497926	4650	·644666	3547	·75726	2727	27
34	·036213	9013	·306615	6249	·500716	4628	·646794	3532	·75880	2715	26
35	·041621	8950	·310364	6216	·503492	4607	·648913	3516	·76049	2703	25
36	·046991	8888	·314094	6182	·506256	4585	·651022	3500	·76201	2692	24
37	·052323	8827	·317803	6148	·509007	4563	·653122	3485	·76356	2680	23
38	·057619	8767	·321492	6115	·511745	4542	·655213	3469	·76514	2668	22
39	·062879	8707	·325161	6083	·514470	4521	·657294	3455	·76614	2657	21
40	9·068103	8648	9·328811	6052	9·517183	4500	9·659367	3440	9·76808	2645	20
41	9·073292	8590	9·332442	6019	9·519883	4479	9·661430	3425	9·77094	2633	19
42	·078446	8532	·336053	5987	·522570	4458	·663485	3409	·77174	2622	18
43	·083565	8477	·339645	5956	·525245	4438	·665530	3395	·77247	2610	17
44	·088651	8419	·343219	5924	·527908	4418	·667567	3379	·77312	2598	16
45	·093702	8363	·346773	5893	·530559	4397	·669594	3365	·77371	2586	15
46	·098720	8308	·350309	5863	·533197	4377	·671613	3350	·77922	2575	14
47	·103706	8254	·353827	5832	·535823	4357	·673623	3336	·77467	2563	13
48	·108658	8201	·357326	5802	·538437	4338	·675621	3322	·78005	2552	12
49	·113579	8148	·360807	5772	·541040	4318	·677617	3307	·78536	2541	11
50	9·118468	8095	9·364270	5742	9·543630	4298	9·679601	3292	9·78061	2530	10
51	9·123325	8043	9·367715	5712	9·546208	4278	9·681576	3278	9·79578	2518	9
52	·128151	7992	·371142	5683	·548775	4258	·683543	3263	·79089	2507	8
53	·132946	7942	·374552	5654	·551330	4239	·685501	3249	·78593	2495	7
54	·137711	7892	·377945	5625	·553874	4220	·687450	3235	·80090	2484	6
55	·142446	7842	·381320	5597	·556406	4200	·689391	3221	·91580	2473	5
56	·147151	7793	·384678	5568	·558926	4182	·691324	3207	·93064	2462	4
57	·151826	7744	·388018	5540	·561435	4163	·693248	3193	·94541	2451	3
58	·156473	7696	·391342	5512	·563933	4144	·695163	3179	·96012	2440	2
59	·161090	7648	·394650	5484	·566419	4125	·697071	3165	·97476	2428	1
60	9·165679		9·397940		9·568894		9·698970		9·98933		0

Min.	21 Hours.	Diff. 100 sec.	20 Hours.	Diff. 100 sec.	19 Hours.	Diff. 100 sec.	18 Hours.	Diff. 100 sec.	7 Hours.	Diff. 100 sec.	Min.

TABLE VI.

(0°) Logarithmic Sines.

′	Sine	D.	Cosec.	Tang.	D.	Cotang.	Secant	D.	Cosine	
0			Infinite.	0.000000		Infinite.	10.000000		10.000000	60
1	6.463726	501717	13.536274	6.463726	501717	13.536274	000000	00	000000	59
2	764756	293485	235244	764756	293485	235244	000000	00	000000	58
3	940847	208231	059153	940847	208231	059153	000000	00	000000	57
4	7.065786	161517	12.934214	7.065786	161517	12.934214	000000	00	000000	56
5	162696	131968	837304	162696	131969	837304	000000	00	000000	55
6	241877	111578	758123	241878	111578	758122	000001	01	9.999999	54
7	308824	96653	691176	308825	96653	691175	000001	01	999999	53
8	366816	85254	633184	366817	85254	633183	000001	01	999999	52
9	417968	76262	582032	417970	76263	582030	000001	01	999999	51
10	463725	68988	536275	463727	68988	536273	000002	01	999998	50
11	7.505118	62981	12.494882	7.505120	62981	12.494880	10.000002	01	9.999998	49
12	542906	57936	457094	542909	57938	457091	000003	01	999997	48
13	577668	53641	422332	577672	53642	422328	000003	01	999997	47
14	609853	49938	390147	609857	49939	390143	000004	01	999996	46
15	639816	46714	360184	639820	46715	360180	000004	01	999996	45
16	667845	43881	332155	667849	43882	332151	000005	01	999995	44
17	694173	41372	305827	694179	41373	305821	000005	01	999995	43
18	718997	39135	281003	719003	39136	280997	000006	01	999994	42
19	742477	37127	257523	742484	37128	257516	000007	01	999993	41
20	764754	35315	235246	764761	35316	235239	000007	01	999993	40
21	7.785943	33672	12.214057	7.785951	33673	12.214049	10.000008	01	9.999992	39
22	806146	32175	193854	806155	32176	193845	000009	01	999991	38
23	825451	30805	174549	825460	30807	174540	000010	01	999990	37
24	843934	29547	156066	843944	29549	156056	000011	02	999989	36
25	861662	28388	138338	861674	28390	138326	000011	02	999989	35
26	878695	27317	121305	878708	27318	121292	000012	02	999988	34
27	895095	26323	104915	895099	26325	104901	000013	02	999987	33
28	910870	25399	089121	910894	25401	089106	000014	02	999986	32
29	926119	24538	073881	926134	24540	073866	000015	02	999985	31
30	940842	23733	059158	940858	23735	059142	000017	02	999983	30
31	7.955085	22980	12.044918	7.955100	22982	12.044900	10.000018	02	9.999982	29
32	968870	22273	031130	968889	22275	031111	000019	02	999981	28
33	982233	21608	017767	982253	21610	017747	000020	02	999980	27
34	995198	20981	004802	995219	20983	004781	000021	02	999979	26
35	8.007787	20390	11.992213	8.007809	20392	11.992191	000023	02	999977	25
36	020021	19831	979979	020045	19833	979955	000024	02	999976	24
37	031919	19302	968081	031945	19305	968055	000025	02	999975	23
38	043501	18801	956499	043527	18803	956473	000027	02	999973	22
39	054781	18325	945219	054809	18327	945191	000028	02	999972	21
40	065776	17872	934224	065806	17875	934194	000029	02	999971	20
41	8.076500	17441	11.923500	8.076531	17444	11.923469	10.000031	02	9.999969	19
42	086965	17031	913035	086997	17034	913003	000032	02	999968	18
43	097183	16639	902817	097217	16642	902783	000034	02	999966	17
44	107167	16265	892833	107202	16268	892798	000036	03	999964	16
45	116926	15908	883074	116963	15912	883037	000037	03	999963	15
46	126471	15566	873529	126510	15568	873490	000039	03	999961	14
47	135810	15238	864190	135851	15241	864149	000041	03	999959	13
48	144953	14924	855047	144996	14927	855004	000042	03	999958	12
49	153907	14622	846093	153952	14625	846048	000044	03	999956	11
50	162681	14333	837319	162727	14336	837273	000046	03	999954	10
51	8.171280	14054	11.828720	8.171328	14057	11.828672	10.000048	03	9.999952	9
52	179713	13786	820287	179763	13790	820237	000050	03	999950	8
53	187985	13529	812015	188036	13532	811964	000052	03	999948	7
54	196102	13280	803898	196156	13284	803844	000054	03	999946	6
55	204070	13041	795930	204126	13044	795874	000056	03	999944	5
56	211895	12810	788105	211953	12814	788047	000058	04	999942	4
57	219581	12587	780419	219641	12590	780359	000060	04	999940	3
58	227134	12372	772866	227195	12376	772805	000062	04	999938	2
59	234557	12164	765443	234621	12168	765379	000064	04	999936	1
60	241855		758145	241921		758079	000066		999934	0
	Cosine		Secant	Cotang.		Tang.	Cosec.		Sine	′

Tangents and Secants. (1°.)

′	Sine	D.	Cosec.	Tang.	D.	Cotang.	Secant	D.	Cosine	
0	8.241855	11963	11.758145	8.241921	11967	11.758079	10.000066	04	9.999934	60
1	249033	11768	750967	249102	11772	750898	000068	04	999932	59
2	256094	11580	743906	256165	11584	743835	000071	04	999929	58
3	263042	11398	736958	263115	11402	736885	000073	04	999927	57
4	269881	11221	730119	269956	11225	730044	000075	04	999925	56
5	276614	11050	723386	276691	11054	723309	000078	04	999922	55
6	283243	10883	716757	283323	10887	716677	000080	04	999920	54
7	289773	10723	710227	289856	10726	710144	000082	04	999918	53
8	296207	10565	703793	296292	10570	703708	000085	04	999915	52
9	302546	10413	697454	302634	10418	697366	000087	04	999913	51
10	308794	10266	691206	308884	10270	691116	000090	04	999910	50
11	8.314954	10122	11.685046	8.315046	10126	11.684954	10.000093	04	9.999907	49
12	321027	9982	678973	321122	9987	678878	000095	04	999905	48
13	327016	9847	672984	327114	9851	672886	000098	04	999902	47
14	332924	9714	667076	333025	9719	666975	000101	05	999899	46
15	338753	9586	661247	338856	9590	661144	000103	05	999897	45
16	344504	9460	655496	344610	9465	655390	000106	05	999894	44
17	350181	9338	649819	350289	9343	649711	000109	05	999891	43
18	355783	9219	644217	355895	9224	644105	000112	05	999888	42
19	361315	9103	638685	361436	9108	638570	000115	05	999885	41
20	366777	8990	633223	366895	8995	633105	000118	05	999882	40
21	8.372171	8880	11.627829	8.372292	8885	11.627708	10.000121	05	9.999879	39
22	377499	8772	622501	377622	8777	622378	000124	05	999876	38
23	382762	8667	617238	382889	8672	617111	000127	05	999873	37
24	387962	8564	612038	388092	8570	611908	000130	05	999870	36
25	393101	8464	606899	393234	8470	606766	000133	05	999867	35
26	398179	8366	601821	398315	8371	601685	000136	05	999864	34
27	403199	8271	596801	403338	8276	596662	000139	05	999861	33
28	408161	8177	591839	408304	8182	591696	000142	05	999858	32
29	413068	8086	586932	413213	8091	586787	000146	05	999854	31
30	417919	7996	582081	418068	8002	581932	000149	06	999851	30
31	8.422717	7909	11.577283	8.422869	7914	11.577131	10.000152	06	9.999848	29
32	427462	7823	572538	427618	7828	572382	000156	06	999844	28
33	432156	7740	567844	432315	7745	567685	000159	06	999841	27
34	436800	7657	563200	436962	7663	563038	000162	06	999838	26
35	441394	7577	558606	441560	7583	558440	000166	06	999834	25
36	445941	7499	554059	446110	7505	553890	000169	06	999831	24
37	450440	7422	549560	450613	7428	549387	000173	06	999827	23
38	454893	7346	545107	455070	7352	544930	000177	06	999823	22
39	459301	7273	540699	459481	7279	540519	000180	06	999820	21
40	463665	7200	536335	463849	7206	536151	000184	06	999816	20
41	8.467985	7129	11.532015	8.468172	7135	11.531828	10.000188	06	9.999812	19
42	472263	7060	527737	472454	7066	527546	000191	06	999809	18
43	476498	6991	523502	476693	6998	523307	000195	06	999805	17
44	480693	6924	519307	480892	6931	519108	000199	06	999801	16
45	484848	6859	515152	485050	6865	514950	000203	07	999797	15
46	488963	6794	511037	489170	6801	510830	000207	07	999793	14
47	493040	6731	506960	493250	6738	506750	000210	07	999790	13
48	497078	6669	502922	497293	6676	502707	000214	07	999786	12
49	501080	6608	498920	501298	6615	498702	000218	07	999782	11
50	505045	6548	494955	505267	6555	494733	000222	07	999778	10
51	8.508974	6489	11.491026	8.509200	6496	11.490800	10.000226	07	9.999774	9
52	512867	6432	487133	513098	6439	486902	000231	07	999769	8
53	516726	6375	483274	516961	6382	483039	000235	07	999765	7
54	520551	6319	479449	520790	6326	479210	000239	07	999761	6
55	524343	6264	475657	524586	6272	475414	000243	07	999757	5
56	528102	6211	471898	528349	6218	471651	000247	07	999753	4
57	531828	6158	468172	532080	6165	467920	000252	07	999748	3
58	535523	6106	464477	535779	6113	464221	000256	07	999744	2
59	539186	6055	460814	539447	6062	460553	000260	07	999740	1
60	542819		457181	543084		456916	000265		999735	0
	Cosine		Secant	Cotang.		Tang.	Cosec.		Sine	′

TABLE VI.

(2°) Logarithmic Sines.

′	Sine.	D.	Cosec.	Tang.	D.	Cotang.	Secant.	D.	Cosine.	
0	8.542819	6004	11.457181	8.543084	6012	11.456916	10.000265	07	9.999735	60
1	546422	5955	453578	546691	5962	453309	000269	07	999731	59
2	549995	5906	450005	550268	5914	449732	000274	07	999726	58
3	553539	5858	446461	553817	5866	446183	000278	08	999722	57
4	557054	5811	442946	557336	5819	442664	000283	08	999717	56
5	560540	5765	439460	560828	5773	439172	000287	08	999713	55
6	563999	5719	436001	564291	5727	435709	000292	08	999708	54
7	567431	5674	432569	567727	5682	432273	000296	08	999704	53
8	570836	5630	429164	571137	5638	428863	000301	08	999699	52
9	574214	5587	425786	574520	5595	425480	000306	08	999694	51
10	577566	5544	422434	577877	5552	422123	000311	08	999689	50
11	8.580892	5502	11.419108	8.581208	5510	11.418792	10.000315	08	9.999685	49
12	584193	5460	415807	584514	5468	415486	000320	08	999680	48
13	587469	5419	412531	587795	5427	412205	000325	08	999675	47
14	590721	5379	409279	591051	5387	408949	000330	08	999670	46
15	593948	5339	406052	594283	5347	405717	000335	08	999665	45
16	597152	5300	402848	597492	5308	402508	000340	08	999660	44
17	600332	5261	399668	600677	5270	399323	000345	08	999655	43
18	603489	5223	396511	603839	5232	396161	000350	08	999650	42
19	606623	5186	393377	606978	5194	393022	000355	08	999645	41
20	609734	5149	390266	610094	5158	389906	000360	09	999640	40
21	8.612823	5112	11.387177	8.613189	5121	11.386811	10.000365	09	9.999635	39
22	615891	5076	384109	616262	5085	383738	000371	09	999629	38
23	618937	5041	381063	619313	5050	380687	000376	09	999624	37
24	621962	5006	378038	622343	5015	377657	000381	09	999619	36
25	624965	4972	375035	625352	4981	374648	000386	09	999614	35
26	627948	4938	372052	628340	4947	371660	000392	09	999608	34
27	630911	4904	369089	631308	4913	368692	000397	09	999603	33
28	633854	4871	366146	634256	4880	365744	000403	09	999597	32
29	636776	4839	363224	637184	4848	362816	000408	09	999592	31
30	639680	4806	360320	640093	4816	359907	000414	09	999586	30
31	8.642563	4775	11.357437	8.642982	4784	11.357018	10.000419	09	9.999581	29
32	645428	4743	354572	645853	4753	354147	000425	09	999575	28
33	648274	4712	351726	648704	4722	351296	000430	09	999570	27
34	651102	4682	348898	651537	4691	348463	000436	09	999564	26
35	653911	4652	346089	654352	4661	345648	000442	09	999558	25
36	656702	4622	343298	657149	4631	342851	000447	10	999553	24
37	659475	4592	340525	659928	4602	340072	000453	10	999547	23
38	662230	4563	337770	662689	4573	337311	000459	10	999541	22
39	664968	4535	335032	665433	4544	334567	000465	10	999535	21
40	667689	4506	332311	668160	4517	331840	000471	10	999529	20
41	8.670393	4479	11.329607	8.670870	4488	11.329130	10.000476	10	9.999524	19
42	673080	4451	326920	673563	4461	326437	000482	10	999518	18
43	675751	4424	324249	676239	4434	323761	000488	10	999512	17
44	678405	4397	321595	678900	4407	321100	000494	10	999506	16
45	681043	4370	318957	681544	4380	318456	000500	10	999500	15
46	683665	4344	316335	684172	4354	315828	000507	10	999493	14
47	686272	4318	313728	686784	4328	313216	000513	10	999487	13
48	688863	4292	311137	689381	4303	310619	000519	10	999481	12
49	691438	4267	308562	691963	4277	308037	000525	10	999475	11
50	693998	4242	306002	694529	4252	305471	000531	10	999469	10
51	8.696543	4217	11.303457	8.697081	4228	11.302919	10.000537	11	9.999463	9
52	699073	4192	300927	699617	4203	300383	000544	11	999456	8
53	701589	4168	298411	702139	4179	297861	000550	11	999450	7
54	704090	4144	295910	704646	4155	295354	000557	11	999443	6
55	706577	4121	293423	707140	4132	292860	000563	11	999437	5
56	709049	4097	290951	709618	4108	290382	000569	11	999431	4
57	711507	4074	288493	712083	4085	287917	000576	11	999424	3
58	713952	4051	286048	714534	4062	285466	000582	11	999418	2
59	716383	4029	283617	716972	4040	283028	000589	11	999411	1
60	718800		281200	719396		280604	000596	11	999404	0
	Cosine.		Secant.	Cotang.		Tang.	Cosec.		Sine.	′

Tangents and Secants. (3°)

/	Sine.	D.	Cosec.	Tang.	D.	Cotang.	Secant.	D.	Cosine.	
0	8.718800	4006	11.281200	8.719396	4017	11.280604	10.000596	11	9.999404	60
1	721204	3984	278796	721806	3995	278194	000602	11	999398	59
2	723595	3962	276405	724204	3974	275796	000609	11	999391	58
3	725972	3941	274028	726588	3952	273412	000616	11	999384	57
4	728337	3919	271663	728959	3930	271041	000622	11	999378	56
5	730688	3898	269312	731317	3909	268683	000629	11	999371	55
6	733027	3877	266973	733663	3889	266337	000636	12	999364	54
7	735354	3857	264646	735996	3868	264004	000643	12	999357	53
8	737667	3836	262333	738317	3848	261683	000650	12	999350	52
9	739969	3816	260031	740626	3827	259374	000657	12	999343	51
10	742259	3796	257741	742922	3807	257078	000664	12	999336	50
11	8.744536	3776	11.255464	8.745207	3787	11.254793	10.000671	12	9.999329	49
12	746802	3756	253198	747479	3768	252521	000678	12	999322	48
13	749055	3737	250945	749740	3749	250260	000685	12	999315	47
14	751297	3717	248703	751989	3729	248011	000692	12	999308	46
15	753528	3698	246472	754227	3710	245773	000699	12	999301	45
16	755747	3678	244253	756453	3692	243547	000706	12	999294	44
17	757955	3661	242045	758668	3673	241332	000714	12	999286	43
18	760151	3642	239849	760872	3655	239128	000721	12	999279	42
19	762337	3624	237663	763065	3636	236935	000728	12	999272	41
20	764511	3606	235489	765246	3618	234754	000735	12	999265	40
21	8.766675	3588	11.233325	8.767417	3600	11.232583	10.000743	12	9.999257	39
22	768828	3570	231172	769578	3583	230422	000750	13	999250	38
23	770970	3553	229030	771727	3565	228273	000758	13	999242	37
24	773101	3535	226899	773866	3548	226134	000765	13	999235	36
25	775223	3518	224777	775995	3531	224005	000773	13	999227	35
26	777333	3501	222667	778114	3514	221886	000780	13	999220	34
27	779434	3484	220566	780222	3497	219778	000788	13	999212	33
28	781524	3467	218476	782320	3480	217680	000795	13	999205	32
29	783605	3451	216395	784408	3464	215592	000803	13	999197	31
30	785675	3434	214325	786486	3447	213514	000811	13	999189	30
31	8.787736	3418	11.212264	8.788554	3431	11.211446	10.000819	13	9.999181	29
32	789787	3402	210213	790613	3415	209387	000826	13	999174	28
33	791828	3386	208172	792662	3399	207338	000834	13	999166	27
34	793859	3370	206141	794701	3383	205299	000842	13	999158	26
35	795881	3354	204119	796731	3368	203269	000850	13	999150	25
36	797894	3339	202106	798752	3352	201248	000858	13	999142	24
37	799897	3323	200103	800763	3337	199237	000866	13	999134	23
38	801892	3308	198108	802765	3322	197235	000874	13	999126	22
39	803876	3293	196124	804758	3307	195242	000882	13	999118	21
40	805852	3278	194148	806742	3292	193258	000890	13	999110	20
41	8.807819	3263	11.192181	8.808717	3277	11.191283	10.000898	13	9.999102	19
42	809777	3249	190223	810683	3262	189317	000906	14	999094	18
43	811726	3234	188274	812641	3248	187359	000914	14	999086	17
44	813667	3219	186333	814589	3233	185411	000923	14	999077	16
45	815599	3205	184401	816529	3219	183471	000931	14	999069	15
46	817522	3191	182478	818461	3205	181539	000939	14	999061	14
47	819436	3177	180564	820384	3191	179616	000947	14	999053	13
48	821343	3163	178657	822298	3177	177702	000956	14	999044	12
49	823240	3149	176760	824205	3163	175795	000964	14	999036	11
50	825130	3135	174870	826103	3150	173897	000973	14	999027	10
51	8.827011	3122	11.172989	8.827992	3136	11.172008	10.000981	14	9.999019	9
52	828884	3108	171116	829874	3123	170126	000990	14	999010	8
53	830749	3095	169251	831748	3108	168252	000998	14	999002	7
54	832607	3082	167393	833613	3096	166387	001007	14	998993	6
55	834456	3069	165544	835471	3083	164529	001016	14	998984	5
56	836297	3056	163703	837321	3070	162679	001024	14	998976	4
57	838130	3043	161870	839163	3057	160837	001033	15	998967	3
58	839956	3030	160044	840998	3045	159002	001042	15	998958	2
59	841774	3017	158226	842825	3032	157175	001050	15	998950	1
60	843585		156415	844644		155356	001059		998941	0
	Cosine.		Secant.	Cotang.		Tang.	Cosec.		Sine.	/

TABLE VI.

(4°) Logarithmic Sines.

′	Sine.	D.	Cosec.	Tang.	D.	Cotang.	Secant.	D.	Cosine.	
0	8.843585	3005	11.156415	8.844644	3019	11.155356	10.001059	15	9.998941	60
1	845387	2992	154613	846455	3007	153545	001068	15	998932	59
2	847183	2980	152817	848260	2995	151740	001077	15	998923	58
3	848971	2967	151029	850057	2982	149943	001086	15	998914	57
4	850751	2955	149249	851846	2970	148154	001095	15	998905	56
5	852525	2943	147475	853628	2958	146372	001104	15	998896	55
6	854291	2931	145709	855403	2946	144597	001113	15	998887	54
7	856049	2919	143951	857171	2935	142829	001122	15	998878	53
8	857801	2908	142199	858932	2923	141068	001131	15	998869	52
9	859546	2896	140454	860686	2911	139314	001140	15	998860	51
10	861283	2884	138717	862433	2900	137567	001149	15	998851	50
11	8.863014	2873	11.136986	8.864173	2888	11.135827	10.001159	15	9.998841	49
12	864738	2861	135262	865906	2877	134094	001168	15	998832	48
13	866455	2850	133545	867632	2866	132368	001177	16	998823	47
14	868165	2839	131835	869351	2854	130649	001187	16	998813	46
15	869868	2828	130132	871064	2843	128936	001196	16	998804	45
16	871565	2817	128435	872770	2832	127230	001205	16	998795	44
17	873255	2806	126745	874469	2821	125531	001215	16	998785	43
18	874938	2795	125062	876162	2811	123838	001224	16	998776	42
19	876615	2783	123385	877849	2800	122151	001234	16	998766	41
20	878285	2773	121715	879529	2789	120471	001243	16	998757	40
21	8.879949	2763	11.120051	8.881202	2779	11.118798	10.001253	16	9.998747	39
22	881607	2752	118393	882869	2768	117131	001262	16	998738	38
23	883258	2742	116742	884530	2758	115470	001272	16	998728	37
24	884903	2731	115097	886185	2747	113815	001282	16	998718	36
25	886542	2721	113458	887833	2737	112167	001292	16	998708	35
26	888174	2711	111826	889476	2727	110524	001301	16	998699	34
27	889801	2700	110199	891112	2717	108888	001311	16	998689	33
28	891421	2690	108579	892742	2707	107258	001321	16	998679	32
29	893035	2680	106965	894366	2697	105634	001331	16	998669	31
30	894643	2670	105357	895984	2687	104016	001341	17	998659	30
31	8.896246	2660	11.103754	8.897596	2677	11.102404	10.001351	17	9.998649	29
32	897842	2651	102158	899203	2667	100797	001361	17	998639	28
33	899432	2641	100568	900803	2658	099197	001371	17	998629	27
34	901017	2631	098983	902398	2648	097602	001381	17	998619	26
35	902596	2622	097404	903987	2638	096013	001391	17	998609	25
36	904169	2612	095831	905570	2629	094430	001401	17	998599	24
37	905736	2603	094264	907147	2620	092853	001411	17	998589	23
38	907297	2593	092703	908719	2610	091281	001422	17	998578	22
39	908853	2584	091147	910285	2601	089715	001432	17	998568	21
40	910404	2575	089596	911846	2592	088154	001442	17	998558	20
41	8.911949	2566	11.088051	8.913401	2583	11.086599	10.001452	17	9.998548	19
42	913488	2556	086512	914951	2574	085049	001463	17	998537	18
43	915022	2547	084978	916495	2565	083505	001473	17	998527	17
44	916550	2538	083450	918034	2556	081966	001484	18	998516	16
45	918073	2529	081927	919568	2547	080432	001494	18	998506	15
46	919591	2520	080409	921096	2538	078904	001505	18	998495	14
47	921103	2512	078897	922619	2530	077381	001515	18	998485	13
48	922610	2503	077390	924136	2521	075864	001526	18	998474	12
49	924112	2494	075888	925649	2512	074351	001536	18	998464	11
50	925609	2486	074391	927156	2503	072844	001547	18	998453	10
51	8.927100	2477	11.072900	8.928658	2495	11.071342	10.001558	18	9.998442	9
52	928587	2469	071413	930155	2486	069845	001569	18	998431	8
53	930068	2460	069932	931647	2478	068353	001579	18	998421	7
54	931544	2452	068456	933134	2470	066866	001590	18	998410	6
55	933015	2443	066985	934616	2461	065384	001601	18	998399	5
56	934481	2435	065519	936093	2453	063907	001612	18	998388	4
57	935942	2427	064058	937565	2445	062435	001623	18	998377	3
58	937398	2419	062602	939032	2437	060968	001634	18	998366	2
59	938850	2411	061150	940494	2430	059506	001645	18	998355	1
60	940296		059704	941952		058048	001656		998344	0
	Cosine.		Secant.	Cotang.		Tang.	Cosec.		Sine.	′

Tangents and Secants. (5°)

′	Sine.	D.	Cosec.	Tang.	D.	Cotang.	Secant.	D.	Cosine.	
0	8.940296	2403	11.059704	8.941952	2421	11.058048	10.001656	19	9.998344	60
1	941738	2394	058262	943404	2413	056596	001667	19	998333	59
2	943174	2387	056826	944852	2405	055148	001678	19	998322	58
3	944606	2379	055394	946295	2397	053705	001689	19	998311	57
4	946034	2371	053966	947734	2390	052266	001700	19	998300	56
5	947456	2363	052544	949168	2382	050832	001711	19	998289	55
6	948874	2355	051126	950597	2374	049403	001723	19	998277	54
7	950287	2348	049713	952021	2366	047979	001734	19	998266	53
8	951696	2340	048304	953441	2358	046559	001745	19	998255	52
9	953100	2332	046900	954856	2351	045144	001757	19	998243	51
10	954499	2325	045501	956267	2344	043733	001768	19	998232	50
11	8.955894	2317	11.044106	8.957674	2335	11.042326	10.001780	19	9.998220	49
12	957284	2310	042716	959075	2329	040925	001791	19	998209	48
13	958670	2302	041330	960473	2321	039527	001803	19	998197	47
14	960052	2295	039948	961866	2314	038134	001814	19	998186	46
15	961429	2288	038571	963255	2307	036745	001826	19	998174	45
16	962801	2280	037199	964639	2300	035361	001837	19	998163	44
17	964170	2273	035830	966019	2293	033981	001849	19	998151	43
18	965534	2266	034466	967394	2286	032606	001861	19	998139	42
19	966893	2259	033107	968766	2279	031234	001872	20	998128	41
20	968249	2252	031751	970133	2271	029867	001884	20	998116	40
21	8.969600	2245	11.030400	8.971496	2265	11.028504	10.001896	20	9.998104	39
22	970947	2238	029053	972855	2257	027145	001908	20	998092	38
23	972289	2231	027711	974209	2251	025791	001920	20	998080	37
24	973628	2224	026372	975560	2244	024440	001932	20	998068	36
25	974962	2217	025038	976906	2237	023094	001944	20	998056	35
26	976293	2210	023707	978248	2230	021752	001956	20	998044	34
27	977619	2203	022381	979586	2223	020414	001968	20	998032	33
28	978941	2197	021059	980921	2217	019079	001980	20	998020	32
29	980259	2190	019741	982251	2210	017749	001992	20	998008	31
30	981573	2183	018427	983577	2204	016423	002004	20	997996	30
31	8.982883	2177	11.017117	8.984899	2197	11.015101	10.002016	20	9.997984	29
32	984189	2170	015811	986217	2191	013783	002028	20	997972	28
33	985491	2163	014509	987532	2184	012468	002041	20	997959	27
34	986789	2157	013211	988842	2178	011158	002053	20	997947	26
35	988083	2150	011917	990149	2171	009851	002065	21	997935	25
36	989374	2144	010626	991451	2165	008549	002078	21	997922	24
37	990660	2138	009340	992750	2158	007250	002090	21	997910	23
38	991943	2131	008057	994045	2152	005955	002103	21	997897	22
39	993222	2125	006778	995337	2146	004663	002115	21	997885	21
40	994497	2119	005503	996624	2140	003376	002128	21	997872	20
41	8.995768	2112	11.004232	8.997908	2134	11.002092	10.002140	21	9.997860	19
42	997036	2106	002964	999188	2127	000812	002153	21	997847	18
43	998299	2100	001701	9.000465	2121	10.999535	002165	21	997835	17
44	999560	2094	000440	001738	2115	998262	002178	21	997822	16
45	9.000816	2088	10.999184	003007	2109	996993	002191	21	997809	15
46	002069	2082	997931	004272	2103	995728	002203	21	997797	14
47	003318	2076	996682	005534	2097	994466	002216	21	997784	13
48	004563	2070	995437	006792	2091	993208	002229	21	997771	12
49	005805	2064	994195	008047	2085	991953	002242	21	997758	11
50	007044	2058	992956	009298	2080	990702	002255	21	997745	10
51	9.008278	2052	10.991722	9.010546	2074	10.989454	10.002268	21	9.997732	9
52	009510	2046	990490	011790	2068	988210	002281	21	997719	8
53	010737	2040	989263	013031	2062	986969	002294	21	997706	7
54	011962	2034	988038	014268	2056	985732	002307	22	997693	6
55	013182	2029	986818	015502	2051	984498	002320	22	997680	5
56	014400	2023	985600	016732	2045	983268	002333	22	997667	4
57	015613	2017	984387	017959	2040	982041	002346	22	997654	3
58	016824	2012	983176	019183	2033	980817	002359	22	997641	2
59	018031	2006	981969	020403	2028	979597	002372	22	997628	1
60	019235		980765	021620		978380	002386		997614	0
	Cosine.		Secant.	Cotang.		Tang.	Cosec.		Sine.	′

TABLE VI.

(6°) Logarithmic Sines.

′	Sine.	D.	Cosec.	Tang.	D.	Cotang.	Secant.	D.	Cosine.	
0	9.019235	2000	10.980765	9.021620	2023	10.978380	10.002386	22	9.997614	60
1	020435	1995	979565	022834	2017	977166	002399	22	997601	59
2	021632	1989	978368	024044	2011	975956	002412	22	997588	58
3	022825	1984	977175	025251	2006	974749	002426	22	997574	57
4	024016	1978	975984	026455	2000	973545	002439	22	997561	56
5	025203	1973	974797	027655	1995	972345	002453	22	997547	55
6	026386	1967	973614	028852	1990	971148	002466	23	997534	54
7	027567	1962	972433	030046	1985	969954	002480	23	997520	53
8	028744	1957	971256	031237	1979	968763	002493	23	997507	52
9	029918	1951	970082	032425	1974	967575	002507	23	997493	51
10	031089	1946	968911	033609	1969	966391	002520	23	997480	50
11	9.032257	1941	10.967743	9.034791	1964	10.965209	10.002534	23	9.997466	49
12	033421	1936	966579	035969	1958	964031	002548	23	997452	48
13	034582	1930	965418	037144	1953	962856	002561	23	997439	47
14	035741	1925	964259	038316	1948	961684	002575	23	997425	46
15	036896	1920	963104	039485	1943	960515	002589	23	997411	45
16	038048	1915	961952	040651	1938	959349	002603	23	997397	44
17	039197	1910	960803	041813	1933	958187	002617	23	997383	43
18	040342	1905	959658	042973	1928	957027	002631	23	997369	42
19	041485	1899	958515	044130	1923	955870	002645	23	997355	41
20	042625	1895	957375	045284	1918	954716	002659	23	997341	40
21	9.043762	1889	10.956238	9.046434	1913	10.953566	10.002673	24	9.997327	39
22	044895	1884	955105	047582	1908	952418	002687	24	997313	38
23	046026	1879	953974	048727	1903	951273	002701	24	997299	37
24	047154	1875	952846	049869	1898	950131	002715	24	997285	36
25	048279	1870	951721	051008	1893	948992	002729	24	997271	35
26	049400	1865	950600	052144	1889	947856	002743	24	997257	34
27	050519	1860	949481	053277	1884	946723	002758	24	997242	33
28	051635	1855	948365	054407	1879	945593	002772	24	997228	32
29	052749	1850	947251	055535	1874	944465	002786	24	997214	31
30	053859	1845	946141	056659	1870	943341	002801	24	997199	30
31	9.054966	1841	10.945034	9.057781	1865	10.942219	10.002815	24	9.997185	29
32	056071	1836	943929	058900	1860	941100	002830	24	997170	28
33	057172	1831	942828	060016	1855	939984	002844	24	997156	27
34	058271	1827	941729	061130	1851	938870	002859	24	997141	26
35	059367	1822	940633	062240	1846	937760	002873	24	997127	25
36	060460	1817	939540	063348	1842	936652	002888	24	997112	24
37	061551	1813	938449	064453	1837	935547	002902	24	997098	23
38	062639	1808	937361	065556	1833	934444	002917	25	997083	22
39	063724	1804	936276	066655	1828	933345	002932	25	997068	21
40	064806	1799	935194	067752	1824	932248	002947	25	997053	20
41	9.065885	1794	10.934115	9.068846	1819	10.931154	10.002961	25	9.997039	19
42	066962	1790	933038	069938	1815	930062	002976	25	997024	18
43	068036	1786	931964	071027	1810	928973	002991	25	997009	17
44	069107	1781	930893	072113	1806	927887	003006	25	996994	16
45	070176	1777	929824	073197	1802	926803	003021	25	996979	15
46	071242	1772	928758	074278	1797	925722	003036	25	996964	14
47	072306	1768	927694	075356	1793	924644	003051	25	996949	13
48	073366	1763	926634	076432	1789	923568	003066	25	996934	12
49	074424	1759	925576	077505	1784	922495	003081	25	996919	11
50	075480	1755	924520	078576	1780	921424	003096	25	996904	10
51	9.076533	1750	10.923467	9.079644	1776	10.920356	10.003111	25	9.996889	9
52	077583	1746	922417	080710	1772	919290	003126	25	996874	8
53	078631	1742	921369	081773	1767	918227	003142	25	996858	7
54	079676	1738	920324	082833	1763	917167	003157	25	996843	6
55	080719	1733	919281	083891	1759	916109	003172	25	996828	5
56	081759	1729	918241	084947	1755	915053	003188	26	996812	4
57	082797	1725	917203	086000	1751	914000	003203	26	996797	3
58	083832	1721	916168	087050	1747	912950	003218	26	996782	2
59	084864	1717	915136	088098	1743	911902	003234	26	996766	1
60	085894		914106	089144		910856	003249		996751	0
	Cosine.		Secant.	Cotang.		Tang.	Cosec.		Sine.	′

Tangents and Secants. (7°)

′	Sine.	D.	Cosec.	Tang.	D.	Cotang.	Secant.	D.	Cosine.	
0	9.085894	1713	10.914106	9.089144	1738	10.910856	10.003249	26	9.996751	60
1	086922	1709	913078	090187	1735	909813	003265	26	996735	59
2	087947	1704	912053	091228	1731	908772	003280	26	996720	58
3	088970	1700	911030	092266	1727	907734	003296	26	996704	57
4	089990	1696	910010	093302	1722	906698	003312	26	996688	56
5	091008	1692	908992	094336	1719	905664	003327	26	996673	55
6	092024	1688	907976	095367	1715	904633	003343	26	996657	54
7	093037	1684	906963	096395	1711	903605	003359	26	996641	53
8	094047	1680	905953	097422	1707	902578	003375	26	996625	52
9	095056	1676	904944	098446	1703	901554	003390	26	996610	51
10	096062	1673	903938	099468	1699	900532	003406	26	996594	50
11	9.097065	1668	10.902935	9.100487	1695	10.899513	10.003422	27	9.996578	49
12	098066	1665	901934	101504	1691	898496	003438	27	996562	48
13	099065	1661	900935	102519	1687	897481	003454	27	996546	47
14	100062	1657	899938	103532	1684	896468	003470	27	996530	46
15	101056	1653	898944	104542	1680	895458	003486	27	996514	45
16	102048	1649	897952	105550	1676	894450	003502	27	996498	44
17	103037	1645	896963	106556	1672	893444	003518	27	996482	43
18	104025	1642	895975	107559	1669	892441	003535	27	996465	42
19	105010	1638	894990	108560	1665	891440	003551	27	996449	41
20	105992	1634	894008	109559	1661	890441	003567	27	996433	40
21	9.106973	1630	10.893027	9.110556	1658	10.889444	10.003583	27	9.996417	39
22	107951	1627	892049	111551	1654	888449	003600	27	996400	38
23	108927	1623	891073	112543	1650	887457	003616	27	996384	37
24	109901	1619	890099	113533	1647	886467	003632	27	996368	36
25	110873	1616	889127	114521	1643	885479	003649	27	996351	35
26	111842	1612	888158	115507	1639	884493	003665	27	996335	34
27	112809	1608	887191	116491	1636	883509	003682	27	996318	33
28	113774	1605	886226	117472	1632	882528	003698	28	996302	32
29	114737	1601	885263	118452	1629	881548	003715	28	996285	31
30	115698	1597	884302	119429	1625	880571	003731	28	996269	30
31	9.116656	1594	10.883344	9.120404	1622	10.879596	10.003748	28	9.996252	29
32	117613	1590	882387	121377	1618	878623	003765	28	996235	28
33	118567	1587	881433	122348	1615	877652	003781	28	996219	27
34	119519	1583	880481	123317	1611	876683	003798	28	996202	26
35	120469	1580	879531	124284	1608	875716	003815	28	996185	25
36	121417	1576	878583	125249	1604	874751	003832	28	996168	24
37	122362	1573	877638	126211	1601	873789	003849	28	996151	23
38	123306	1569	876694	127172	1597	872828	003866	28	996134	22
39	124248	1566	875752	128130	1594	871870	003883	28	996117	21
40	125187	1562	874813	129087	1591	870913	003900	28	996100	20
41	9.126125	1559	10.873875	9.130041	1587	10.869959	10.003917	29	9.996083	19
42	127060	1556	872940	130994	1584	869006	003934	29	996066	18
43	127993	1552	872007	131944	1581	868056	003951	29	996049	17
44	128925	1549	871075	132893	1577	867107	003968	29	996032	16
45	129854	1545	870146	133839	1574	866161	003985	29	996015	15
46	130781	1542	869219	134784	1571	865216	004002	29	995998	14
47	131706	1539	868294	135726	1567	864274	004020	29	995980	13
48	132630	1535	867370	136667	1564	863333	004037	29	995963	12
49	133551	1532	866449	137605	1561	862395	004054	29	995946	11
50	134470	1529	865530	138542	1558	861458	004072	29	995928	10
51	9.135387	1525	10.864613	9.139476	1555	10.860524	10.004089	29	9.995911	9
52	136303	1522	863697	140409	1551	859591	004106	29	995894	8
53	137216	1519	862784	141340	1548	858660	004124	29	995876	7
54	138128	1516	861872	142269	1545	857731	004141	29	995859	6
55	139037	1512	860963	143196	1542	856804	004159	29	995841	5
56	139944	1509	860056	144121	1539	855879	004177	29	995823	4
57	140850	1506	859150	145044	1535	854956	004194	29	995806	3
58	141754	1503	858246	145966	1532	854034	004212	29	995788	2
59	142655	1500	857345	146885	1529	853115	004229	29	995771	1
60	143555		856445	147803		852197	004247		995753	0
	Cosine.		Secant.	Cotang.		Tang.	Cosec.		Sine.	′

TABLE VI.

(8°) Logarithmic Sines.

/	Sine.	D.	Cosec.	Tang.	D.	Cotang.	Secant.	D.	Cosine.	
0	9.143555	1496	10.856445	9.147803	1526	10.852197	10.004247	30	9.995753	60
1	144453	1493	855547	148718	1523	851282	004265	30	995735	59
2	145349	1490	854651	149632	1520	850368	004283	30	995717	58
3	146243	1487	853757	150544	1517	849456	004301	30	995699	57
4	147136	1484	852864	151454	1514	848546	004319	30	995681	56
5	148026	1481	851974	152363	1511	847637	004336	30	995664	55
6	148915	1478	851085	153269	1508	846731	004354	30	995646	54
7	149802	1475	850198	154174	1505	845826	004372	30	995628	53
8	150686	1472	849314	155077	1502	844923	004390	30	995610	52
9	151569	1469	848431	155978	1499	844022	004409	30	995591	51
10	152451	1466	847549	156877	1496	843123	004427	30	995573	50
11	9.153330	1463	10.846670	9.157775	1493	10.842225	10.004445	30	9.995555	49
12	154208	1460	845792	158671	1490	841329	004463	30	995537	48
13	155083	1457	844917	159565	1487	840435	004481	30	995519	47
14	155957	1454	844043	160457	1484	839543	004499	31	995501	46
15	156830	1451	843170	161347	1481	838653	004518	31	995482	45
16	157700	1448	842300	162236	1479	837764	004536	31	995464	44
17	158569	1445	841431	163123	1476	836877	004554	31	995446	43
18	159435	1442	840565	164008	1473	835992	004573	31	995427	42
19	160301	1439	839699	164892	1470	835108	004591	31	995409	41
20	161164	1436	838836	165774	1467	834226	004610	31	995390	40
21	9.162025	1433	10.837975	9.166654	1464	10.833346	10.004628	31	9.995372	39
22	162885	1430	837115	167532	1461	832468	004647	31	995353	38
23	163743	1427	836257	168409	1458	831591	004666	31	995334	37
24	164600	1424	835400	169284	1455	830716	004684	31	995316	36
25	165454	1422	834546	170157	1453	829843	004703	31	995297	35
26	166307	1419	833693	171029	1450	828971	004722	31	995278	34
27	167159	1416	832841	171899	1447	828101	004740	31	995260	33
28	168008	1413	831992	172767	1444	827233	004759	32	995241	32
29	168856	1410	831144	173634	1442	826366	004778	32	995222	31
30	169702	1407	830298	174499	1439	825501	004797	32	995203	30
31	9.170547	1405	10.829453	9.175362	1436	10.824638	10.004816	32	9.995184	29
32	171389	1402	828611	176224	1433	823776	004835	32	995165	28
33	172230	1399	827770	177084	1431	822916	004854	32	995146	27
34	173070	1396	826930	177942	1428	822058	004873	32	995127	26
35	173908	1394	826092	178799	1425	821201	004892	32	995108	25
36	174744	1391	825256	179655	1423	820345	004911	32	995089	24
37	175578	1388	824422	180508	1420	819492	004930	32	995070	23
38	176411	1386	823589	181360	1417	818640	004949	32	995051	22
39	177242	1383	822758	182211	1415	817789	004968	32	995032	21
40	178072	1380	821928	183059	1412	816941	004987	32	995013	20
41	9.178900	1377	10.821100	9.183907	1409	10.816093	10.005007	32	9.994993	19
42	179726	1374	820274	184752	1407	815248	005026	32	994974	18
43	180551	1372	819449	185597	1404	814403	005045	32	994955	17
44	181374	1369	818626	186439	1402	813561	005065	32	994935	16
45	182196	1366	817804	187280	1399	812720	005084	33	994916	15
46	183016	1364	816984	188120	1396	811880	005104	33	994896	14
47	183834	1361	816166	188958	1393	811042	005123	33	994877	13
48	184651	1359	815349	189794	1391	810206	005143	33	994857	12
49	185466	1356	814534	190629	1389	809371	005162	33	994838	11
50	186280	1353	813720	191462	1386	808538	005182	33	994818	10
51	9.187092	1351	10.812908	9.192294	1384	10.807706	10.005202	33	9.994798	9
52	187903	1348	812097	193124	1381	806876	005221	33	994779	8
53	188712	1346	811288	193953	1379	806047	005241	33	994759	7
54	189519	1343	810481	194780	1376	805220	005261	33	994739	6
55	190325	1341	809675	195606	1374	804394	005281	33	994719	5
56	191130	1338	808870	196430	1371	803570	005300	33	994700	4
57	191933	1336	808067	197253	1369	802747	005320	33	994680	3
58	192734	1333	807266	198074	1366	801926	005340	33	994660	2
59	193534	1330	806466	198894	1364	801106	005360	33	994640	1
60	194332		805668	199713		800287	005380		994620	0
	Cosine.		Secant.	Cotang.		Tang.	Cosec.		Sine.	/

TABLE VI.

Tangents and Secants. (9°)

′	Sine.	D.	Cosec.	Tang.	D.	Cotang.	Secant.	D.	Cosine.	
0	9.194332	1328	10.805668	9.199713	1361	10.800287	10.005380	33	9.994620	60
1	195129	1326	804871	200529	1359	799471	005400	33	994600	59
2	195925	1323	804075	201345	1356	798655	005420	33	994580	58
3	196719	1321	803281	202159	1354	797841	005440	34	994560	57
4	197511	1318	802489	202971	1352	797029	005460	34	994540	56
5	198302	1316	801698	203782	1349	796218	005481	34	994519	55
6	199091	1313	800909	204592	1347	795408	005501	34	994499	54
7	199879	1311	800121	205400	1345	794600	005521	34	994479	53
8	200666	1308	799334	206207	1342	793793	005541	34	994459	52
9	201451	1306	798549	207013	1340	792987	005562	34	994438	51
10	202234	1304	797766	207817	1338	792183	005582	34	994418	50
11	9.203017	1301	10.796983	9.208619	1335	10.791381	10.005603	34	9.994397	49
12	203797	1299	796203	209420	1333	790580	005623	34	994377	48
13	204577	1296	795423	210220	1331	789780	005643	34	994357	47
14	205354	1294	794646	211018	1328	788982	005664	34	994336	46
15	206131	1292	793869	211815	1326	788185	005684	34	994316	45
16	206906	1289	793094	212611	1324	787389	005705	34	994295	44
17	207679	1287	792321	213405	1321	786595	005726	35	994274	43
18	208452	1285	791548	214198	1319	785802	005746	35	994254	42
19	209222	1282	790778	214989	1317	785011	005767	35	994233	41
20	209992	1280	790008	215780	1315	784220	005788	35	994212	40
21	9.210760	1278	10.789240	9.216568	1312	10.783432	10.005809	35	9.994191	39
22	211526	1275	788474	217356	1310	782644	005829	35	994171	38
23	212291	1273	787709	218142	1308	781858	005850	35	994150	37
24	213055	1271	786945	218926	1305	781074	005871	35	994129	36
25	213818	1268	786182	219710	1303	780290	005892	35	994108	35
26	214579	1266	785421	220492	1301	779508	005913	35	994087	34
27	215338	1264	784662	221272	1299	778728	005934	35	994066	33
28	216097	1261	783903	222052	1297	777948	005955	35	994045	32
29	216854	1259	783146	222830	1294	777170	005976	35	994024	31
30	217609	1257	782391	223606	1292	776394	005997	35	994003	30
31	9.218363	1255	10.781637	9.224382	1290	10.775618	10.006019	35	9.993981	29
32	219116	1253	780884	225156	1288	774844	006040	35	993960	28
33	219868	1250	780132	225929	1286	774071	006061	35	993939	27
34	220618	1248	779382	226700	1284	773300	006082	35	993918	26
35	221367	1246	778633	227471	1281	772529	006104	36	993896	25
36	222115	1244	777885	228239	1279	771761	006125	36	993875	24
37	222861	1242	777139	229007	1277	770993	006146	36	993854	23
38	223606	1239	776394	229773	1275	770227	006168	36	993832	22
39	224349	1237	775651	230539	1273	769461	006189	36	993811	21
40	225092	1235	774908	231302	1271	768698	006211	36	993789	20
41	9.225833	1233	10.774167	9.232065	1269	10.767935	10.006232	36	9.993768	19
42	226573	1231	773427	232826	1267	767174	006254	36	993746	18
43	227311	1228	772689	233586	1265	766414	006275	36	993725	17
44	228048	1226	771952	234345	1262	765655	006297	36	993703	16
45	228784	1224	771216	235103	1260	764897	006319	36	993681	15
46	229518	1222	770482	235859	1258	764141	006340	36	993660	14
47	230252	1220	769748	236614	1256	763386	006362	36	993638	13
48	230984	1218	769016	237368	1254	762632	006384	36	993616	12
49	231714	1216	768286	238120	1252	761880	006406	37	993594	11
50	232444	1214	767556	238872	1250	761128	006428	37	993572	10
51	9.233172	1212	10.766828	9.239622	1248	10.760378	10.006450	37	9.993550	9
52	233899	1209	766101	240371	1246	759629	006472	37	993528	8
53	234625	1207	765375	241118	1244	758882	006494	37	993506	7
54	235349	1205	764651	241865	1242	758135	006516	37	993484	6
55	236073	1203	763927	242610	1240	757390	006538	37	993462	5
56	236795	1201	763205	243354	1238	756646	006560	37	993440	4
57	237515	1199	762485	244097	1236	755903	006582	37	993418	3
58	238235	1197	761765	244839	1234	755161	006604	37	993396	2
59	238953	1195	761047	245579	1232	754421	006626	37	993374	1
60	239670		760330	246319		753681	006649		993351	0
	Cosine.		Secant.	Cotang.		Tang.	Cosec.		Sine.	′

(10°) Table of Logarithmic Sines.

′	Sine.	D.	Cosec.	Tang.	D.	Cotang.	Secant.	D.	Cosine.	
0	9.239670	1193	10.760330	9.246319	1230	10.753681	10.006649	37	9.993351	60
1	240386	1191	759614	247057	1228	752943	006671	37	993329	59
2	241101	1189	758899	247794	1226	752206	006693	37	993307	58
3	241814	1187	758186	248530	1224	751470	006715	37	993285	57
4	242526	1185	757474	249264	1222	750736	006738	37	993262	56
5	243237	1183	756763	249998	1220	750002	006760	37	993240	55
6	243947	1181	756053	250730	1218	749270	006783	38	993217	54
7	244656	1179	755344	251461	1217	748539	006805	38	993195	53
8	245363	1177	754637	252191	1215	747809	006828	38	993172	52
9	246069	1175	753931	252920	1213	747080	006851	38	993149	51
10	246775	1173	753225	253648	1211	746352	006873	38	993127	50
11	9.247478	1171	10.752522	9.254374	1209	10.745626	10.006896	38	9.993104	49
12	248181	1169	751819	255100	1207	744900	006919	38	993081	48
13	248883	1167	751117	255824	1205	744176	006941	38	993059	47
14	249583	1165	750417	256547	1203	743453	006964	38	993036	46
15	250282	1163	749718	257269	1201	742731	006987	38	993013	45
16	250980	1161	749020	257990	1200	742010	007010	38	992990	44
17	251677	1159	748323	258710	1198	741290	007033	38	992967	43
18	252373	1158	747627	259429	1196	740571	007056	38	992944	42
19	253067	1156	746933	260146	1194	739854	007079	38	992921	41
20	253761	1154	746239	260863	1192	739137	007102	38	992898	40
21	9.254453	1152	10.745547	9.261578	1190	10.738422	10.007125	38	9.992875	39
22	255144	1150	744856	262292	1189	737708	007148	38	992852	38
23	255834	1148	744166	263005	1187	736995	007171	39	992829	37
24	256523	1146	743477	263717	1185	736283	007194	39	992806	36
25	257211	1144	742789	264428	1183	735572	007217	39	992783	35
26	257898	1142	742102	265138	1181	734862	007241	39	992759	34
27	258583	1141	741417	265847	1179	734153	007264	39	992736	33
28	259268	1139	740732	266555	1178	733445	007287	39	992713	32
29	259951	1137	740049	267261	1176	732739	007310	39	992690	31
30	260633	1135	739367	267967	1174	732033	007334	39	992666	30
31	9.261314	1133	10.738686	9.268671	1172	10.731329	10.007357	39	9.992643	29
32	261994	1131	738006	269375	1170	730625	007381	39	992619	28
33	262673	1130	737327	270077	1169	729923	007404	39	992596	27
34	263351	1128	736649	270779	1167	729221	007428	39	992572	26
35	264027	1126	735973	271479	1165	728521	007451	39	992549	25
36	264703	1124	735297	272178	1164	727822	007475	39	992525	24
37	265377	1122	734623	272876	1162	727124	007499	39	992501	23
38	266051	1120	733949	273573	1160	726427	007522	39	992478	22
39	266723	1119	733277	274269	1158	725731	007546	40	992454	21
40	267395	1117	732605	274964	1157	725036	007570	40	992430	20
41	9.268065	1115	10.731935	9.275658	1155	10.724342	10.007594	40	9.992406	19
42	268734	1113	731266	276351	1153	723649	007618	40	992382	18
43	269402	1111	730598	277043	1151	722957	007641	40	992359	17
44	270069	1110	729931	277734	1150	722266	007665	40	992335	16
45	270735	1108	729265	278424	1148	721576	007689	40	992311	15
46	271400	1106	728600	279113	1147	720887	007713	40	992287	14
47	272064	1105	727936	279801	1145	720199	007737	40	992263	13
48	272726	1103	727274	280488	1143	719512	007761	40	992239	12
49	273388	1101	726612	281174	1141	718826	007786	40	992214	11
50	274049	1099	725951	281858	1140	718142	007810	40	992190	10
51	9.274708	1098	10.725292	9.282542	1138	10.717458	10.007834	40	9.992166	9
52	275367	1096	724633	283225	1136	716775	007858	40	992142	8
53	276024	1094	723976	283907	1135	716093	007883	41	992117	7
54	276681	1092	723319	284588	1133	715412	007907	41	992093	6
55	277337	1091	722663	285268	1131	714732	007931	41	992069	5
56	277991	1089	722009	285947	1130	714053	007956	41	992044	4
57	278644	1087	721356	286624	1128	713376	007980	41	992020	3
58	279297	1086	720703	287301	1126	712699	008004	41	991996	2
59	279948	1084	720052	287977	1125	712023	008029	41	991971	1
60	280599		719401	288652		711348	008053		991947	0
	Cosine.		Secant.	Cotang.		Tang.	Cosec.		Sine.	′

TABLE VI.

Tangents and Secants. (11°)

′	Sine.	D.	Cosec.	Tang.	D.	Cotang.	Secant.	D.	Cosine.	
0	9.280599	1082	10.719401	9.288652	1123	10.711348	10.008053	41	9.991947	60
1	281248	1081	718752	289326	1122	710674	008078	41	991922	59
2	281897	1079	718103	289999	1120	710001	008103	41	991897	58
3	282544	1077	717456	290671	1118	709329	008127	41	991873	57
4	283190	1076	716810	291342	1117	708658	008152	41	991848	56
5	283836	1074	716164	292013	1115	707987	008177	41	991823	55
6	284480	1072	715520	292682	1114	707318	008201	41	991799	54
7	285124	1071	714876	293350	1112	706650	008226	42	991774	53
8	285766	1069	714234	294017	1111	705983	008251	42	991749	52
9	286408	1067	713592	294684	1109	705316	008276	42	991724	51
10	287048	1066	712952	295349	1107	704651	008301	42	991699	50
11	9.287687	1064	10.712313	9.296013	1106	10.703987	10.008326	42	9.991674	49
12	288326	1063	711674	296677	1104	703323	008351	42	991649	48
13	288964	1061	711036	297339	1103	702661	008376	42	991624	47
14	289600	1059	710400	298001	1101	701999	008401	42	991599	46
15	290236	1058	709764	298662	1100	701338	008426	42	991574	45
16	290870	1056	709130	299322	1098	700678	008451	42	991549	44
17	291504	1054	708496	299980	1096	700020	008476	42	991524	43
18	292137	1053	707863	300638	1095	699362	008502	42	991498	42
19	292768	1051	707232	301295	1093	698705	008527	42	991473	41
20	293399	1050	706601	301951	1092	698049	008552	42	991448	40
21	9.294029	1048	10.705971	9.302607	1090	10.697393	10.008578	42	9.991422	39
22	294658	1046	705342	303261	1089	696739	008603	42	991397	38
23	295286	1045	704714	303914	1087	696086	008628	43	991372	37
24	295913	1043	704087	304567	1086	695433	008654	43	991346	36
25	296539	1042	703461	305218	1084	694782	008679	43	991321	35
26	297164	1040	702836	305869	1083	694131	008705	43	991295	34
27	297788	1039	702212	306519	1081	693481	008730	43	991270	33
28	298412	1037	701588	307168	1080	692832	008756	43	991244	32
29	299034	1036	700966	307815	1078	692185	008782	43	991218	31
30	299655	1034	700345	308463	1077	691537	008807	43	991193	30
31	9.300276	1032	10.699724	9.309109	1075	10.690891	10.008833	43	9.991167	29
32	300895	1031	699105	309754	1074	690246	008859	43	991141	28
33	301514	1029	698486	310398	1073	689602	008885	43	991115	27
34	302132	1028	697868	311042	1071	688958	008910	43	991090	26
35	302748	1026	697252	311685	1070	688315	008936	43	991064	25
36	303364	1025	696636	312327	1068	687673	008962	43	991038	24
37	303979	1023	696021	312967	1067	687033	008988	43	991012	23
38	304593	1022	695407	313608	1065	686392	009014	43	990986	22
39	305207	1020	694793	314247	1064	685753	009040	43	990960	21
40	305819	1019	694181	314885	1062	685115	009066	44	990934	20
41	9.306430	1017	10.693570	9.315523	1061	10.684477	10.009092	44	9.990908	19
42	307041	1016	692959	316159	1060	683841	009118	44	990882	18
43	307650	1014	692350	316795	1058	683205	009145	44	990855	17
44	308259	1013	691741	317430	1057	682570	009171	44	990829	16
45	308867	1011	691133	318064	1055	681936	009197	44	990803	15
46	309474	1010	690526	318697	1054	681303	009223	44	990777	14
47	310080	1008	689920	319329	1053	680671	009250	44	990750	13
48	310685	1007	689315	319961	1051	680039	009276	44	990724	12
49	311289	1005	688711	320592	1050	679408	009303	44	990697	11
50	311893	1004	688107	321222	1048	678778	009329	44	990671	10
51	9.312495	1003	10.687505	9.321851	1047	10.678149	10.009356	44	9.990644	9
52	313097	1001	686903	322479	1045	677521	009382	44	990618	8
53	313698	1000	686302	323106	1044	676894	009409	44	990591	7
54	314297	998	685703	323733	1043	676267	009435	44	990565	6
55	314897	997	685103	324358	1041	675642	009462	44	990538	5
56	315495	996	684505	324983	1040	675017	009489	44	990511	4
57	316092	994	683908	325607	1039	674393	009515	45	990485	3
58	316689	993	683311	326231	1037	673769	009542	45	990458	2
59	317284	991	682716	326853	1036	673147	009569	45	990431	1
60	317879		682121	327475		672525	009596		990404	0
	Cosine.		Secant.	Cotang.		Tang.	Cosec.		Sine.	′

TABLE VI.

(12°) Logarithmic Sines.

′	Sine.	D.	Cosec.	Tang.	D.	Cotang.	Secant.	D.	Cosine.	
0	9.317879	990	10.682121	9.327474	1035	10.672526	10.009596	45	9.990404	60
1	318473	988	681527	328095	1033	671905	009622	45	990378	59
2	319066	987	680934	328715	1032	671285	009649	45	990351	58
3	319658	986	680344	329334	1030	670666	009676	45	990324	57
4	320249	984	679751	329953	1029	670047	009703	45	990297	56
5	320840	983	679160	330570	1028	669430	009730	45	990270	55
6	321430	982	678570	331187	1026	668813	009757	45	990243	54
7	322019	980	677981	331803	1025	668197	009785	45	990215	53
8	322607	979	677393	332418	1024	667582	009812	45	990188	52
9	323194	977	676806	333033	1023	666967	009839	45	990161	51
10	323780	976	676220	333646	1021	666354	009866	45	990134	50
11	9.324366	975	10.675634	9.334259	1020	10.665741	10.009893	46	9.990107	49
12	324950	973	675050	334871	1019	665129	009921	46	990079	48
13	325534	972	674466	335482	1017	664518	009948	46	990052	47
14	326117	970	673883	336093	1016	663907	009975	46	990025	46
15	326700	969	673300	336702	1015	663298	010003	46	989997	45
16	327281	968	672719	337311	1013	662689	010030	46	989970	44
17	327862	966	672138	337919	1012	662081	010058	46	989942	43
18	328442	965	671558	338527	1011	661473	010085	46	989915	42
19	329021	964	670979	339133	1010	660867	010113	46	989887	41
20	329599	962	670401	339739	1008	660261	010140	46	989860	40
21	9.330176	961	10.669824	9.340344	1007	10.659656	10.010168	46	9.989832	39
22	330753	960	669247	340948	1006	659052	010196	46	989804	38
23	331329	958	668671	341552	1004	658448	010223	46	989777	37
24	331903	957	668097	342155	1003	657845	010251	47	989749	36
25	332478	956	667522	342757	1002	657243	010279	47	989721	35
26	333051	954	666949	343358	1000	656642	010307	47	989693	34
27	333624	953	666376	343958	999	656042	010335	47	989665	33
28	334195	952	665805	344558	998	655442	010363	47	989637	32
29	334766	950	665234	345157	997	654843	010391	47	989609	31
30	335337	949	664663	345755	996	654245	010418	47	989582	30
31	9.335906	948	10.664094	9.346353	994	10.653647	10.010447	47	9.989553	29
32	336475	946	663525	346949	993	653051	010475	47	989525	28
33	337043	945	662957	347545	992	652455	010503	47	989497	27
34	337610	944	662390	348141	991	651859	010531	47	989469	26
35	338176	943	661824	348735	990	651265	010559	47	989441	25
36	338742	941	661258	349329	988	650671	010587	47	989413	24
37	339306	940	660694	349922	987	650078	010616	47	989384	23
38	339871	939	660129	350514	986	649486	010644	47	989356	22
39	340434	937	659566	351106	985	648894	010672	47	989328	21
40	340996	936	659004	351697	983	648303	010700	47	989300	20
41	9.341558	935	10.658442	9.352287	982	10.647713	10.010729	47	9.989271	19
42	342119	934	657881	352876	981	647124	010757	47	989243	18
43	342679	932	657321	353465	980	646535	010786	47	989214	17
44	343239	931	656761	354053	979	645947	010814	47	989186	16
45	343797	930	656203	354640	977	645360	010843	47	989157	15
46	344355	929	655645	355227	976	644773	010872	47	989128	14
47	344912	927	655088	355813	975	644187	010900	48	989100	13
48	345469	926	654531	356398	974	643602	010929	48	989071	12
49	346024	925	653976	356982	973	643018	010958	48	989042	11
50	346579	924	653421	357566	971	642434	010986	48	989014	10
51	9.347134	922	10.652866	9.358149	970	10.641851	10.011015	48	9.988985	9
52	347687	921	652313	358731	969	641269	011044	48	988956	8
53	348240	920	651760	359313	968	640687	011073	48	988927	7
54	348792	919	651208	359893	967	640107	011102	48	988898	6
55	349343	917	650657	360474	966	639526	011131	48	988869	5
56	349893	916	650107	361053	965	638947	011160	48	988840	4
57	350443	915	649557	361632	963	638368	011189	49	988811	3
58	350992	914	649008	362210	962	637790	011218	49	988782	2
59	351540	913	648460	362787	961	637213	011247	49	988753	1
60	352088		647912	363364		636636	011276		988724	0
	Cosine.		Secant.	Cotang.		Tang.	Cosec.		Sine.	′

Tangents and Secants. (13°)

′	Sine.	D.	Cosec.	Tang.	D.	Cotang.	Secant.	D.	Cosine.	
0	9.352088	911	10.647912	9.363364	960	10.636636	10.011276	49	9.988724	60
1	352635	910	647365	363940	959	636060	011305	49	988695	59
2	353181	909	646819	364515	958	635485	011334	49	988666	58
3	353726	908	646274	365090	957	634910	011364	49	988636	57
4	354271	907	645729	365664	955	634336	011393	49	988607	56
5	354815	905	645185	366237	954	633763	011422	49	988578	55
6	355358	904	644642	366810	953	633190	011452	49	988548	54
7	355901	903	644099	367382	952	632618	011481	49	988519	53
8	356443	902	643557	367953	951	632047	011511	49	988489	52
9	356984	901	643016	368524	950	631476	011540	49	988460	51
10	357524	899	642476	369094	949	630906	011570	49	988430	50
11	9.358064	898	10.641936	9.369663	948	10.630337	10.011599	49	9.988401	49
12	358603	897	641397	370232	946	629768	011629	49	988371	48
13	359141	896	640859	370799	945	629201	011658	49	988342	47
14	359678	895	640322	371367	944	628633	011688	50	988312	46
15	360215	893	639785	371933	943	628067	011718	50	988282	45
16	360752	892	639248	372499	942	627501	011748	50	988252	44
17	361287	891	638713	373064	941	626936	011777	50	988223	43
18	361822	890	638178	373629	940	626371	011807	50	988193	42
19	362356	889	637644	374193	939	625807	011837	50	988163	41
20	362889	888	637111	374756	938	625244	011867	50	988133	40
21	9.363422	887	10.636578	9.375319	937	10.624681	10.011897	50	9.988103	39
22	363954	885	636046	375881	935	624119	011927	50	988073	38
23	364485	884	635515	376442	934	623558	011957	50	988043	37
24	365016	883	634984	377003	933	622997	011987	50	988013	36
25	365546	882	634454	377563	932	622437	012017	50	987983	35
26	366075	881	633925	378122	931	621878	012047	50	987953	34
27	366604	880	633396	378681	930	621319	012078	50	987922	33
28	367131	879	632869	379239	929	620761	012108	50	987892	32
29	367659	877	632341	379797	928	620203	012138	50	987862	31
30	368185	876	631815	380354	927	619646	012168	51	987832	30
31	9.368711	875	10.631289	9.380910	926	10.619090	10.012199	51	9.987801	29
32	369236	874	630764	381466	925	618534	012229	51	987771	28
33	369761	873	630239	382020	924	617980	012260	51	987740	27
34	370285	872	629715	382575	923	617425	012290	51	987710	26
35	370808	871	629192	383129	922	616871	012321	51	987679	25
36	371330	870	628670	383682	921	616318	012351	51	987649	24
37	371852	869	628148	384234	920	615766	012382	51	987618	23
38	372373	867	627627	384786	919	615214	012412	51	987588	22
39	372894	866	627106	385337	918	614663	012443	51	987557	21
40	373414	865	626586	385888	917	614112	012474	51	987526	20
41	9.373933	864	10.626067	9.386438	915	10.613562	10.012504	51	9.987496	19
42	374452	863	625548	386987	914	613013	012535	51	987465	18
43	374970	862	625030	387536	913	612464	012566	51	987434	17
44	375487	861	624513	388084	912	611916	012597	52	987403	16
45	376003	860	623997	388631	911	611369	012628	52	987372	15
46	376519	859	623481	389178	910	610822	012659	52	987341	14
47	377035	858	622965	389724	909	610276	012690	52	987310	13
48	377549	857	622451	390270	908	609730	012721	52	987279	12
49	378063	856	621937	390815	907	609185	012752	52	987248	11
50	378577	854	621423	391360	906	608640	012783	52	987217	10
51	9.379089	853	10.620911	9.391903	905	10.608097	10.012814	52	9.987186	9
52	379601	852	620399	392447	904	607553	012845	52	987155	8
53	380113	851	619887	392989	903	607011	012876	52	987124	7
54	380624	850	619376	393531	902	606469	012908	52	987092	6
55	381134	849	618866	394073	901	605927	012939	52	987061	5
56	381643	848	618357	394614	900	605386	012970	52	987030	4
57	382152	847	617848	395154	899	604846	013002	52	986998	3
58	382661	846	617339	395694	898	604306	013033	52	986967	2
59	383168	845	616832	396233	897	603767	013064	52	986936	1
60	383675		616325	396771		603229	013096		986904	0
	Cosine.		Secant.	Cotang.		Tang.	Cosec.		Sine.	′

TABLE VI.

(14°) Logarithmic Sines.

′	Sine	D.	Cosec.	Tang.	D.	Cotang.	Secant	D.	Cosine	
0	9.383675	844	10.616325	9.396771	896	10.603229	10.013096	52	9.986904	60
1	384182	843	615818	397309	896	602691	013127	53	986873	59
2	384687	842	615313	397846	895	602154	013159	53	986841	58
3	385192	841	614808	398383	894	601617	013191	53	986809	57
4	385697	840	614303	398919	893	601081	013222	53	986778	56
5	386201	839	613799	399455	892	600545	013254	53	986746	55
6	386704	838	613296	399990	891	600010	013286	53	986714	54
7	387207	837	612793	400524	890	599476	013317	53	986683	53
8	387709	836	612291	401058	889	598942	013349	53	986651	52
9	388210	835	611790	401591	888	598409	013381	53	986619	51
10	388711	834	611289	402124	887	597876	013413	53	986587	50
11	9.389211	833	10.610789	9.402656	886	10.597344	10.013445	53	9.986555	49
12	389711	832	610289	403187	885	596813	013477	53	986523	48
13	390210	831	609790	403718	884	596282	013509	53	986491	47
14	390708	830	609292	404249	883	595751	013541	53	986459	46
15	391206	828	608794	404778	882	595222	013573	53	986427	45
16	391703	827	608297	405308	881	594692	013605	53	986395	44
17	392199	826	607801	405836	880	594164	013637	54	986363	43
18	392695	825	607305	406364	879	593636	013669	54	986331	42
19	393191	824	606809	406892	878	593108	013701	54	986299	41
20	393685	823	606315	407419	877	592581	013734	54	986266	40
21	9.394179	822	10.605821	9.407945	876	10.592055	10.013766	54	9.986234	39
22	394673	821	605327	408471	875	591529	013798	54	986202	38
23	395166	820	604834	408997	874	591003	013831	54	986169	37
24	395658	819	604342	409521	874	590479	013863	54	986137	36
25	396150	818	603850	410045	873	589955	013896	54	986104	35
26	396641	817	603359	410569	872	589431	013928	54	986072	34
27	397132	817	602868	411092	871	588908	013961	54	986039	33
28	397621	816	602379	411615	870	588385	013993	54	986007	32
29	398111	815	601889	412137	869	587863	014026	54	985974	31
30	398600	814	601400	412658	868	587342	014058	54	985942	30
31	9.399088	813	10.600912	9.413179	867	10.586821	10.014091	55	9.985909	29
32	399575	812	600425	413699	866	586301	014124	55	985876	28
33	400062	811	599938	414219	865	585781	014157	55	985843	27
34	400549	810	599451	414738	864	585262	014189	55	985811	26
35	401035	809	598965	415257	864	584743	014222	55	985778	25
36	401520	808	598480	415775	863	584225	014255	55	985745	24
37	402005	807	597995	416293	862	583707	014288	55	985712	23
38	402489	806	597511	416810	861	583190	014321	55	985679	22
39	402972	805	597028	417326	860	582674	014354	55	985646	21
40	403455	804	596545	417842	859	582158	014387	55	985613	20
41	9.403938	803	10.596062	9.418358	858	10.581642	10.014420	55	9.985580	19
42	404420	802	595580	418873	857	581127	014453	55	985547	18
43	404901	801	595099	419387	856	580613	014486	55	985514	17
44	405382	800	594618	419901	855	580099	014520	55	985480	16
45	405862	799	594138	420415	855	579585	014553	55	985447	15
46	406341	798	593659	420927	854	579073	014586	56	985414	14
47	406820	797	593180	421440	853	578560	014620	56	985380	13
48	407299	796	592701	421952	852	578048	014653	56	985347	12
49	407777	795	592223	422463	851	577537	014686	56	985314	11
50	408254	794	591746	422974	850	577026	014720	56	985280	10
51	9.408731	794	10.591269	9.423484	849	10.576516	10.014753	56	9.985247	9
52	409207	793	590793	423993	848	576007	014787	56	985213	8
53	409682	792	590318	424503	848	575497	014820	56	985180	7
54	410157	791	589843	425011	847	574989	014854	56	985146	6
55	410632	790	589368	425519	846	574481	014887	56	985113	5
56	411106	789	588894	426027	845	573973	014921	56	985079	4
57	411579	788	588421	426534	844	573466	014955	56	985045	3
58	412052	787	587948	427041	843	572959	014989	56	985011	2
59	412524	786	587476	427547	843	572453	015022	56	984978	1
60	412996		587004	428052		571948	015056		984944	0
	Cosine		Secant	Cotang.		Tang.	Cosec.		Sine	′

Tangents and Secants. (15°)

′	Sine	D.	Cosec.	Tang.	D.	Cotang.	Secant	D.	Cosine	
0	9.412996	785	10.587004	9.428052	842	10.571948	10.015056	57	9.984944	60
1	413467	784	586533	428557	841	571443	015090	57	984910	59
2	413938	783	586062	429062	840	570938	015124	57	984876	58
3	414408	783	585592	429566	839	570434	015158	57	984842	57
4	414878	782	585122	430070	838	569930	015192	57	984808	56
5	415347	781	584653	430573	838	569427	015226	57	984774	55
6	415815	780	584185	431075	837	568925	015260	57	984740	54
7	416283	779	583717	431577	836	568423	015294	57	984706	53
8	416751	778	583249	432079	835	567921	015328	57	984672	52
9	417217	777	582783	432580	834	567420	015363	57	984637	51
10	417684	776	582316	433080	833	566920	015397	57	984603	50
11	9.418150	775	10.581850	9.433580	832	10.566420	10.015431	57	9.984569	49
12	418615	774	581385	434080	832	565920	015465	57	984535	48
13	419079	773	580921	434579	831	565421	015500	57	984500	47
14	419544	773	580456	435078	830	564922	015534	57	984466	46
15	420007	772	579993	435576	829	564424	015568	58	984432	45
16	420470	771	579530	436073	828	563927	015603	58	984397	44
17	420933	770	579067	436570	828	563430	015637	58	984363	43
18	421395	769	578605	437067	827	562933	015672	58	984328	42
19	421857	768	578143	437563	826	562437	015706	58	984294	41
20	422318	767	577682	438059	825	561941	015741	58	984259	40
21	9.422778	767	10.577222	9.438554	824	10.561446	10.015776	58	9.984224	39
22	423238	766	576762	439048	823	560952	015810	58	984190	38
23	423697	765	576303	439543	823	560457	015845	58	984155	37
24	424156	764	575844	440036	822	559964	015880	58	984120	36
25	424615	763	575385	440529	821	559471	015915	58	984085	35
26	425073	762	574927	441022	820	558978	015950	58	984050	34
27	425530	761	574470	441514	819	558486	015985	58	984015	33
28	425987	760	574013	442006	819	557994	016019	58	983981	32
29	426443	760	573557	442497	818	557503	016054	58	983946	31
30	426899	759	573101	442988	817	557012	016089	58	983911	30
31	9.427354	758	10.572646	9.443479	816	10.556521	10.016125	58	9.983875	29
32	427809	757	572191	443968	816	556032	016160	59	983840	28
33	428263	756	571737	444458	815	555542	016195	59	983805	27
34	428717	755	571283	444947	814	555053	016230	59	983770	26
35	429170	754	570830	445435	813	554565	016265	59	983735	25
36	429623	753	570377	445923	812	554077	016300	59	983700	24
37	430075	752	569925	446411	812	553589	016336	59	983664	23
38	430527	752	569473	446898	811	553102	016371	59	983629	22
39	430978	751	569022	447384	810	552616	016406	59	983594	21
40	431429	750	568571	447870	809	552130	016442	59	983558	20
41	9.431879	749	10.568121	9.448356	809	10.551644	10.016477	59	9.983523	19
42	432329	749	567671	448841	808	551159	016513	59	983487	18
43	432778	748	567222	449326	807	550674	016548	59	983452	17
44	433226	747	566774	449810	806	550190	016584	59	983416	16
45	433675	746	566325	450294	806	549706	016619	59	983381	15
46	434122	745	565878	450777	805	549223	016655	59	983345	14
47	434569	744	565431	451260	804	548740	016691	59	983309	13
48	435016	744	564984	451743	803	548257	016727	59	983273	12
49	435462	743	564538	452225	802	547775	016762	60	983238	11
50	435908	742	564092	452706	802	547294	016798	60	983202	10
51	9.436353	741	10.563647	9.453187	801	10.546813	10.016834	60	9.983166	9
52	436798	740	563202	453668	800	546332	016870	60	983130	8
53	437242	740	562758	454148	799	545852	016906	60	983094	7
54	437686	739	562314	454628	799	545372	016942	60	983058	6
55	438129	738	561871	455107	798	544893	016978	60	983022	5
56	438572	737	561428	455586	797	544414	017014	60	982986	4
57	439014	736	560986	456064	796	543936	017050	60	982950	3
58	439456	736	560544	456542	796	543458	017086	60	982914	2
59	439897	735	560103	457019	795	542981	017122	60	982878	1
60	440338		559662	457496		542504	017158		982842	0
	Cosine		Secant	Cotang		Tang.	Cosec.		Sine	′

TABLE VI.

(16°) Logarithmic Sines.

′	Sine.	D.	Cosec.	Tang.	D.	Cotang.	Secant.	D.	Cosine.	
0	9.440338	734	10.559662	9.457496	794	10.542504	10.017158	60	9.982842	60
1	440778	733	559222	457973	793	542027	017195	60	982805	59
2	441218	732	558782	458449	793	541551	017231	61	982769	58
3	441658	731	558342	458925	792	541075	017267	61	982733	57
4	442096	731	557904	459400	791	540600	017304	61	982696	56
5	442535	730	557465	459875	790	540125	017340	61	982660	55
6	442973	729	557027	460349	790	539651	017376	61	982624	54
7	443410	728	556590	460823	789	539177	017413	61	982587	53
8	443847	727	556153	461297	788	538703	017449	61	982551	52
9	444284	727	555716	461770	788	538230	017486	61	982514	51
10	444720	726	555280	462242	787	537758	017523	61	982477	50
11	9.445155	725	10.554845	9.462714	786	10.537286	10.017559	61	9.982441	49
12	445590	724	554410	463186	785	536814	017596	61	982404	48
13	446025	723	553975	463658	785	536342	017633	61	982367	47
14	446459	723	553541	464129	784	535871	017669	61	982331	46
15	446893	722	553107	464599	783	535401	017706	61	982294	45
16	447326	721	552674	465069	783	534931	017743	61	982257	44
17	447759	720	552241	465539	782	534461	017780	62	982220	43
18	448191	720	551809	466008	781	533992	017817	62	982183	42
19	448623	719	551377	466476	780	533524	017854	62	982146	41
20	449054	718	550946	466945	780	533055	017891	62	982109	40
21	9.449485	717	10.550515	9.467413	779	10.532587	10.017928	62	9.982072	39
22	449915	716	550085	467880	778	532120	017965	62	982035	38
23	450345	716	549655	468347	778	531653	018002	62	981998	37
24	450775	715	549225	468814	777	531186	018039	62	981961	36
25	451204	714	548796	469280	776	530720	018076	62	981924	35
26	451632	713	548368	469746	775	530254	018114	62	981886	34
27	452060	713	547940	470211	775	529789	018151	62	981849	33
28	452488	712	547512	470676	774	529324	018188	62	981812	32
29	452915	711	547085	471141	773	528859	018226	62	981774	31
30	453342	710	546658	471605	773	528395	018263	62	981737	30
31	9.453768	710	10.546232	9.472068	772	10.527932	10.018301	63	9.981699	29
32	454194	709	545806	472532	771	527468	018338	63	981662	28
33	454619	708	545381	472995	771	527005	018375	63	981625	27
34	455044	707	544956	473457	770	526543	018413	63	981587	26
35	455469	707	544531	473919	769	526081	018451	63	981549	25
36	455893	706	544107	474381	769	525619	018488	63	981512	24
37	456316	705	543684	474842	768	525158	018526	63	981474	23
38	456739	704	543261	475303	767	524697	018564	63	981436	22
39	457162	704	542838	475763	767	524237	018601	63	981399	21
40	457584	703	542416	476223	766	523777	018639	63	981361	20
41	9.458006	702	10.541994	9.476683	765	10.523317	10.018677	63	9.981323	19
42	458427	701	541573	477142	765	522858	018715	63	981285	18
43	458848	701	541152	477601	764	522399	018753	63	981247	17
44	459268	700	540732	478059	763	521941	018791	63	981209	16
45	459688	699	540312	478517	763	521483	018829	63	981171	15
46	460108	698	539892	478975	762	521025	018867	64	981133	14
47	460527	698	539473	479432	761	520568	018905	64	981095	13
48	460946	697	539054	479889	761	520111	018943	64	981057	12
49	461364	696	538636	480345	760	519655	018981	64	981019	11
50	461782	695	538218	480801	759	519199	019019	64	980981	10
51	9.462199	695	10.537801	9.481257	759	10.518743	10.019058	64	9.980942	9
52	462616	694	537384	481712	758	518288	019096	64	980904	8
53	463032	693	536968	482167	757	517833	019134	64	980866	7
54	463448	693	536552	482621	757	517379	019173	64	980827	6
55	463864	692	536136	483075	756	516925	019211	64	980789	5
56	464279	691	535721	483529	755	516471	019250	64	980750	4
57	464694	690	535306	483982	755	516018	019288	64	980712	3
58	465108	690	534892	484435	754	515565	019327	64	980673	2
59	465522	689	534478	484887	753	515113	019365	64	980635	1
60	465935		534065	485339		514661	019404		980596	0
	Cosine.		Secant.	Cotang.		Tang.	Cosec.		Sine.	′

Tangents and Secants. (17°)

′	Sine.	D.	Cosec.	Tang.	D.	Cotang.	Secant.	D.	Cosine.	
0	9.465935	688	10.534065	9.485339	753	10.514661	10.019404	64	9.980596	60
1	466348	688	533652	485791	752	514209	019442	64	980558	59
2	466761	687	533239	486242	751	513758	019481	65	980519	58
3	467173	686	532827	486693	751	513307	019520	65	980480	57
4	467585	685	532415	487143	750	512857	019558	65	980442	56
5	467996	685	532004	487593	749	512407	019597	65	980403	55
6	468407	684	531593	488043	749	511957	019636	65	980364	54
7	468817	683	531183	488492	748	511508	019675	65	980325	53
8	469227	683	530773	488941	747	511059	019714	65	980286	52
9	469637	682	530363	489390	747	510610	019753	65	980247	51
10	470046	681	529954	489838	746	510162	019792	65	980208	50
11	9.470455	680	10.529545	9.490286	746	10.509714	10.019831	65	9.980169	49
12	470863	680	529137	490733	745	509267	019870	65	980130	48
13	471271	679	528729	491180	744	508820	019909	65	980091	47
14	471679	678	528321	491627	744	508373	019948	65	980052	46
15	472086	678	527914	492073	743	507927	019988	65	980012	45
16	472492	677	527508	492519	743	507481	020027	65	979973	44
17	472898	676	527102	492965	742	507035	020066	66	979934	43
18	473304	676	526696	493410	741	506590	020105	66	979895	42
19	473710	675	526290	493854	740	506146	020145	66	979855	41
20	474115	674	525885	494299	740	505701	020184	66	979816	40
21	9.474519	674	10.525481	9.494743	740	10.505257	10.020224	66	9.979776	39
22	474923	673	525077	495186	739	504814	020263	66	979737	38
23	475327	672	524673	495630	738	504370	020303	66	979697	37
24	475730	672	524270	496073	737	503927	020342	66	979658	36
25	476133	671	523867	496515	737	503485	020382	66	979618	35
26	476536	670	523464	496957	736	503043	020421	66	979579	34
27	476938	669	523062	497399	736	502601	020461	66	979539	33
28	477340	669	522660	497841	735	502159	020501	66	979499	32
29	477741	668	522259	498282	734	501718	020541	66	979459	31
30	478142	667	521858	498722	734	501278	020580	66	979420	30
31	9.478542	667	10.521458	9.499163	733	10.500837	10.020620	66	9.979380	29
32	478942	666	521058	499603	733	500397	020660	66	979340	28
33	479342	665	520658	500042	732	499958	020700	67	979300	27
34	479741	665	520259	500481	731	499519	020740	67	979260	26
35	480140	664	519860	500920	731	499080	020780	67	979220	25
36	480539	663	519461	501359	730	498641	020820	67	979180	24
37	480937	663	519063	501797	730	498203	020860	67	979140	23
38	481334	662	518666	502235	729	497765	020900	67	979100	22
39	481731	661	518269	502672	728	497328	020941	67	979059	21
40	482128	661	517872	503109	728	496891	020981	67	979019	20
41	9.482525	660	10.517475	9.503546	727	10.496454	10.021021	67	9.978979	19
42	482921	659	517079	503982	727	496018	021061	67	978939	18
43	483316	659	516684	504418	726	495582	021102	67	978898	17
44	483712	658	516288	504854	725	495146	021142	67	978858	16
45	484107	657	515893	505289	725	494711	021183	67	978817	15
46	484501	657	515499	505724	724	494276	021223	67	978777	14
47	484895	656	515105	506159	724	493841	021264	67	978736	13
48	485289	655	514711	506593	723	493407	021304	67	978696	12
49	485682	655	514318	507027	722	492973	021345	68	978655	11
50	486075	654	513925	507460	722	492540	021385	68	978615	10
51	9.486467	653	10.513533	9.507893	721	10.492107	10.021426	68	9.978574	9
52	486860	653	513140	508326	721	491674	021467	68	978533	8
53	487251	652	512749	508759	720	491241	021507	68	978493	7
54	487643	651	512357	509191	719	490809	021548	68	978452	6
55	488034	651	511966	509622	719	490378	021589	68	978411	5
56	488424	650	511576	510054	718	489946	021630	68	978370	4
57	488814	650	511186	510485	718	489515	021671	68	978329	3
58	489204	649	510796	510916	717	489084	021712	68	978288	2
59	489593	648	510407	511346	716	488654	021753	68	978247	1
60	489982		510018	511776		488224	021794		978206	0
	Cosine.		Secant.	Cotang.		Tang.	Cosec.		Sine.	′

TABLE VI.

(18°) Logarithmic Sines.

′	Sine.	D.	Cosec.	Tang.	D.	Cotang.	Secant.	D.	Cosine.	
0	9.489982	648	10.510018	9.511776	716	10.488224	10.021794	68	9.978206	60
1	490371	648	509629	512206	716	487794	021835	68	978165	59
2	490759	647	509241	512635	715	487365	021876	68	978124	58
3	491147	646	508853	513064	714	486936	021917	69	978083	57
4	491535	646	508465	513493	714	486507	021958	69	978042	56
5	491922	645	508078	513921	713	486079	021999	69	978001	55
6	492308	644	507692	514349	713	485651	022041	69	977959	54
7	492695	644	507305	514777	712	485223	022082	69	977918	53
8	493081	643	506919	515204	712	484796	022123	69	977877	52
9	493466	642	506534	515631	711	484369	022165	69	977835	51
10	493851	642	506149	516057	710	483943	022206	69	977794	50
11	9.494236	641	10.505764	9.516484	710	10.483516	10.022248	69	9.977752	49
12	494621	641	505379	516910	709	483090	022289	69	977711	48
13	495005	640	504995	517335	709	482665	022331	69	977669	47
14	495388	639	504612	517761	708	482239	022372	69	977628	46
15	495772	639	504228	518185	708	481815	022414	69	977586	45
16	496154	638	503846	518610	707	481390	022456	70	977544	44
17	496537	637	503463	519034	706	480966	022497	70	977503	43
18	496919	637	503081	519458	706	480542	022539	70	977461	42
19	497301	636	502699	519882	705	480118	022581	70	977419	41
20	497682	636	502318	520305	705	479695	022623	70	977377	40
21	9.498064	635	10.501936	9.520728	704	10.479272	10.022665	70	9.977335	39
22	498444	634	501556	521151	703	478849	022707	70	977293	38
23	498825	634	501175	521573	703	478427	022749	70	977251	37
24	499204	633	500796	521995	703	478005	022791	70	977209	36
25	499584	632	500416	522417	702	477583	022833	70	977167	35
26	499963	632	500037	522838	702	477162	022875	70	977125	34
27	500342	631	499658	523259	701	476741	022917	70	977083	33
28	500721	631	499279	523680	701	476320	022959	70	977041	32
29	501099	630	498901	524100	700	475900	023001	70	976999	31
30	501476	629	498524	524520	699	475480	023043	70	976957	30
31	9.501854	629	10.498146	9.524939	699	10.475061	10.023086	70	9.976914	29
32	502231	628	497769	525359	698	474641	023128	71	976872	28
33	502607	628	497393	525778	698	474222	023170	71	976830	27
34	502984	627	497016	526197	697	473803	023213	71	976787	26
35	503360	626	496640	526615	697	473385	023255	71	976745	25
36	503735	626	496265	527033	696	472967	023298	71	976702	24
37	504110	625	495890	527451	696	472549	023340	71	976660	23
38	504485	625	495515	527868	695	472132	023383	71	976617	22
39	504860	624	495140	528285	695	471715	023426	71	976574	21
40	505234	623	494766	528702	694	471298	023468	71	976532	20
41	9.505608	623	10.494392	9.529119	693	10.470881	10.023511	71	9.976489	19
42	505981	622	494019	529535	693	470465	023554	71	976446	18
43	506354	622	493646	529950	693	470050	023596	71	976404	17
44	506727	621	493273	530366	692	469634	023639	71	976361	16
45	507099	620	492901	530781	691	469219	023682	71	976318	15
46	507471	620	492529	531196	691	468804	023725	71	976275	14
47	507843	619	492157	531611	690	468389	023768	72	976232	13
48	508214	619	491786	532025	690	467975	023811	72	976189	12
49	508585	618	491415	532439	689	467561	023854	72	976146	11
50	508956	618	491044	532853	689	467147	023897	72	976103	10
51	9.509326	617	10.490674	9.533266	688	10.466734	10.023940	72	9.976060	9
52	509696	616	490304	533679	688	466321	023983	72	976017	8
53	510065	616	489935	534092	687	465908	024026	72	975974	7
54	510434	615	489566	534504	687	465496	024070	72	975930	6
55	510803	615	489197	534916	686	465084	024113	72	975887	5
56	511172	614	488828	535328	686	464672	024156	72	975844	4
57	511540	613	488460	535739	685	464261	024200	72	975800	3
58	511907	613	488093	536150	685	463850	024243	72	975757	2
59	512275	612	487725	536561	684	463439	024286	72	975714	1
60	512642		487358	536972		463028	024330		975670	0
	Cosine.		Secant.	Cotang.		Tang.	Cosec.		Sine.	′

Tangents and Secants. (19°)

′	Sine.	D.	Cosec.	Tang.	D.	Cotang.	Secant.	D.	Cosine.	
0	9.512642	612	10.487358	9.536972	684	10.463028	10.024330	73	9.975670	60
1	513009	611	486991	537382	683	462618	024373	73	975627	59
2	513375	611	486625	537792	683	462208	024417	73	975583	58
3	513741	610	486259	538202	682	461798	024461	73	975539	57
4	514107	609	485893	538611	682	461389	024504	73	975496	56
5	514472	609	485528	539020	681	460980	024548	73	975452	55
6	514837	608	485163	539429	681	460571	024592	73	975408	54
7	515202	608	484798	539837	680	460163	024635	73	975365	53
8	515566	607	484434	540245	680	459755	024679	73	975321	52
9	515930	607	484070	540653	679	459347	024723	73	975277	51
10	516294	606	483706	541061	679	458939	024767	73	975233	50
11	9.516657	605	10.483343	9.541468	678	10.458532	10.024811	73	9.975189	49
12	517020	605	482980	541875	678	458125	024855	73	975145	48
13	517382	604	482618	542281	677	457719	024899	73	975101	47
14	517745	604	482255	542688	677	457312	024943	73	975057	46
15	518107	603	481893	543094	676	456906	024987	73	975013	45
16	518468	603	481532	543499	676	456501	025031	74	974969	44
17	518829	602	481171	543905	675	456095	025075	74	974925	43
18	519190	601	480810	544310	675	455690	025120	74	974880	42
19	519551	601	480449	544715	674	455285	025164	74	974836	41
20	519911	600	480089	545119	674	454881	025208	74	974792	40
21	9.520271	600	10.479729	9.545524	673	10.454476	10.025252	74	9.974748	39
22	520631	599	479369	545928	673	454072	025297	74	974703	38
23	520990	599	479010	546331	672	453669	025341	74	974659	37
24	521349	598	478651	546735	672	453265	025386	74	974614	36
25	521707	598	478293	547138	671	452862	025430	74	974570	35
26	522066	597	477934	547540	671	452460	025475	74	974525	34
27	522424	596	477576	547943	670	452057	025519	74	974481	33
28	522781	596	477219	548345	670	451655	025564	74	974436	32
29	523138	595	476862	548747	669	451253	025609	74	974391	31
30	523495	595	476505	549149	669	450851	025653	75	974347	30
31	9.523852	594	10.476148	9.549550	668	10.450450	10.025698	75	9.974302	29
32	524208	594	475792	549951	668	450049	025743	75	974257	28
33	524564	593	475436	550352	667	449648	025788	75	974212	27
34	524920	593	475080	550752	667	449248	025833	75	974167	26
35	525275	592	474725	551152	666	448848	025878	75	974122	25
36	525630	591	474370	551552	666	448448	025923	75	974077	24
37	525984	591	474016	551952	665	448048	025968	75	974032	23
38	526339	590	473661	552351	665	447649	026013	75	973987	22
39	526693	590	473307	552750	665	447250	026058	75	973942	21
40	527046	589	472954	553149	664	446851	026103	75	973897	20
41	9.527400	589	10.472600	9.553548	664	10.446452	10.026148	75	9.973852	19
42	527753	588	472247	553946	663	446054	026193	75	973807	18
43	528105	588	471895	554344	663	445656	026239	75	973761	17
44	528458	587	471542	554741	662	445259	026284	76	973716	16
45	528810	587	471190	555139	662	444861	026329	76	973671	15
46	529161	586	470839	555536	661	444464	026375	76	973625	14
47	529513	586	470487	555933	661	444067	026420	76	973580	13
48	529864	585	470136	556329	660	443671	026465	76	973535	12
49	530215	585	469785	556725	660	443275	026511	76	973489	11
50	530565	584	469435	557121	659	442879	026556	76	973444	10
51	9.530915	584	10.469085	9.557517	659	10.442483	10.026602	76	9.973398	9
52	531265	583	468735	557913	659	442087	026648	76	973352	8
53	531614	582	468386	558308	658	441692	026693	76	973307	7
54	531963	582	468037	558702	658	441298	026739	76	973261	6
55	532312	581	467688	559097	657	440903	026785	76	973215	5
56	532661	581	467339	559491	657	440509	026831	76	973169	4
57	533009	580	466991	559885	656	440115	026876	76	973124	3
58	533357	580	466643	560279	656	439721	026922	76	973078	2
59	533704	579	466296	560673	655	439327	026968	77	973032	1
60	534052		465948	561066		438934	027014		972986	0
	Cosine.		Secant.	Cotang.		Tang.	Cosec.		Sine.	′

TABLE VI.

(20°) Logarithmic Sines.

′	Sine.	D.	Cosec.	Tang.	D.	Cotang.	Secant.	D.	Cosine.	
0	9.534052	578	10.465948	9.561066	655	10.438934	10.027014	77	9.972986	60
1	534399	577	465601	561459	654	438541	027060	77	972940	59
2	534745	577	465255	561851	654	438149	027106	77	972894	58
3	535092	577	464908	562244	653	437756	027152	77	972848	57
4	535438	576	464562	562636	653	437364	027198	77	972802	56
5	535783	576	464217	563028	653	436972	027245	77	972755	55
6	536129	575	463871	563419	652	436581	027291	77	972709	54
7	536474	574	463526	563811	652	436189	027337	77	972663	53
8	536818	574	463182	564202	651	435798	027383	77	972617	52
9	537163	573	462837	564592	651	435408	027430	77	972570	51
10	537507	573	462493	564983	650	435017	027476	77	972524	50
11	9.537851	572	10.462149	9.565373	650	10.434627	10.027522	77	9.972478	49
12	538194	572	461806	565763	649	434237	027569	78	972431	48
13	538538	571	461462	566153	649	433847	027615	78	972385	47
14	538880	571	461120	566542	649	433458	027662	78	972338	46
15	539223	570	460777	566932	648	433068	027709	78	972291	45
16	539565	570	460435	567320	648	432680	027755	78	972245	44
17	539907	569	460093	567709	647	432291	027802	78	972198	43
18	540249	569	459751	568098	647	431902	027849	78	972151	42
19	540590	568	459410	568486	646	431514	027895	78	972105	41
20	540931	568	459069	568873	646	431127	027942	78	972058	40
21	9.541272	567	10.458728	9.569261	645	10.430739	10.027989	78	9.972011	39
22	541613	567	458387	569648	645	430352	028036	78	971964	38
23	541953	566	458047	570035	645	429965	028083	78	971917	37
24	542293	566	457707	570422	644	429578	028130	78	971870	36
25	542632	565	457368	570809	644	429191	028177	78	971823	35
26	542971	565	457029	571195	643	428805	028224	78	971776	34
27	543310	564	456690	571581	643	428419	028271	79	971729	33
28	543649	564	456351	571967	642	428033	028318	79	971682	32
29	543987	563	456013	572352	642	427648	028365	79	971635	31
30	544325	563	455675	572738	642	427262	028412	79	971588	30
31	9.544663	562	10.455337	9.573123	641	10.426877	10.028460	79	9.971540	29
32	545000	562	455000	573507	641	426493	028507	79	971493	28
33	545338	561	454662	573892	640	426108	028554	79	971446	27
34	545674	561	454326	574276	640	425724	028602	79	971398	26
35	546011	560	453989	574660	639	425340	028649	79	971351	25
36	546347	560	453653	575044	639	424956	028697	79	971303	24
37	546683	559	453317	575427	639	424573	028744	79	971256	23
38	547019	559	452981	575810	638	424190	028792	79	971208	22
39	547354	558	452646	576193	638	423807	028839	79	971161	21
40	547689	558	452311	576576	637	423424	028887	79	971113	20
41	9.548024	557	10.451976	9.576958	637	10.423042	10.028934	80	9.971066	19
42	548359	557	451641	577341	636	422659	028982	80	971018	18
43	548693	556	451307	577723	636	422277	029030	80	970970	17
44	549027	556	450973	578104	636	421896	029078	80	970922	16
45	549360	555	450640	578486	635	421514	029126	80	970874	15
46	549693	555	450307	578867	635	421133	029173	80	970827	14
47	550026	554	449974	579248	634	420752	029221	80	970779	13
48	550359	554	449641	579629	634	420371	029269	80	970731	12
49	550692	553	449308	580009	634	419991	029317	80	970683	11
50	551024	553	448976	580389	633	419611	029365	80	970635	10
51	9.551356	552	10.448644	9.580769	633	10.419231	10.029414	80	9.970586	9
52	551687	552	448313	581149	632	418851	029462	80	970538	8
53	552018	552	447982	581528	632	418472	029510	80	970490	7
54	552349	551	447651	581907	632	418093	029558	80	970442	6
55	552680	551	447320	582286	631	417714	029606	80	970394	5
56	553010	550	446990	582665	631	417335	029655	81	970345	4
57	553341	550	446659	583043	630	416957	029703	81	970297	3
58	553670	549	446330	583422	630	416578	029751	81	970249	2
59	554000	549	446000	583800	629	416200	029800	81	970200	1
60	554329		445671	584177		415823	029848		970152	0
	Cosine.		Secant.	Cotang.		Tang.	Cosec.		Sine.	′

Tangents and Secants. (21°)

′	Sine.	D.	Cosec.	Tang.	D	Cotang.	Secant.	D.	Cosine.	
0	9.554329	548	10.445671	9.584177	629	10.415823	10.029848	81	9.970152	60
1	554658	548	445342	584555	629	415445	029897	81	970103	59
2	554987	547	445013	584932	628	415068	029945	81	970055	58
3	555315	547	444685	585309	628	414691	029994	81	970006	57
4	555643	546	444357	585686	627	414314	030043	81	969957	56
5	555971	546	444029	586062	627	413938	030091	81	969909	55
6	556299	545	443701	586439	627	413561	030140	81	969860	54
7	556626	545	443374	586815	626	413185	030189	81	969811	53
8	556953	544	443047	587190	626	412810	030238	81	969762	52
9	557280	544	442720	587566	625	412434	030286	81	969714	51
10	557606	543	442394	587941	625	412059	030335	81	969665	50
11	9.557932	543	10.442068	9.588316	625	10.411684	10.030384	82	9.969616	49
12	558258	543	441742	588691	624	411309	030433	82	969567	48
13	558583	542	441417	589066	624	410934	030482	82	969518	47
14	558909	542	441091	589440	623	410560	030531	82	969469	46
15	559234	541	440766	589814	623	410186	030580	82	969420	45
16	559558	541	440442	590188	623	409812	030630	82	969370	44
17	559883	540	440117	590562	622	409438	030679	82	969321	43
18	560207	540	439793	590935	622	409065	030728	82	969272	42
19	560531	539	439469	591308	622	408692	030777	82	969223	41
20	560855	539	439145	591681	621	408319	030827	82	969173	40
21	9.561178	538	10.438822	9.592054	621	10.407946	10.030876	82	9.969124	39
22	561501	538	438499	592426	620	407574	030925	82	969075	38
23	561824	537	438176	592798	620	407202	030975	82	969025	37
24	562146	537	437854	593171	619	406829	031024	82	968976	36
25	562468	536	437532	593542	619	406458	031074	82	968926	35
26	562790	536	437210	593914	618	406086	031123	83	968877	34
27	563112	536	436888	594285	618	405715	031173	83	968827	33
28	563433	535	436567	594656	618	405344	031223	83	968777	32
29	563755	535	436245	595027	617	404973	031272	83	968728	31
30	564075	534	435925	595398	617	404602	031322	83	968678	30
31	9.564396	534	10.435604	9.595768	617	10.404232	10.031372	83	9.968628	29
32	564716	533	435284	596138	616	403862	031422	83	968578	28
33	565036	533	434964	596508	616	403492	031472	83	968528	27
34	565356	532	434644	596878	616	403122	031521	83	968479	26
35	565676	532	434324	597247	615	402753	031571	83	968429	25
36	565995	531	434005	597616	615	402384	031621	83	968379	24
37	566314	531	433686	597985	615	402015	031671	83	968329	23
38	566632	531	433368	598354	615	401646	031722	83	968278	22
39	566951	530	433049	598722	614	401278	031772	84	968228	21
40	567269	530	432731	599091	614	400909	031822	84	968178	20
41	9.567587	529	10.432413	9.599459	613	10.400541	10.031872	84	9.968128	19
42	567904	529	432096	599827	613	400173	031922	84	968078	18
43	568222	528	431778	600194	612	399806	031973	84	968027	17
44	568539	528	431461	600562	612	399438	032023	84	967977	16
45	568856	528	431144	600929	611	399071	032073	84	967927	15
46	569172	527	430828	601296	611	398704	032124	84	967876	14
47	569488	527	430512	601662	611	398338	032174	84	967826	13
48	569804	526	430196	602029	610	397971	032225	84	967775	12
49	570120	526	429880	602395	610	397605	032275	84	967725	11
50	570435	525	429565	602761	610	397239	032326	84	967674	10
51	9.570751	525	10.429249	9.603127	609	10.396873	10.032376	84	9.967624	9
52	571066	524	428934	603493	609	396507	032427	84	967573	8
53	571380	524	428620	603858	609	396142	032478	85	967522	7
54	571695	523	428305	604223	608	395777	032529	85	967471	6
55	572009	523	427991	604588	608	395412	032579	85	967421	5
56	572323	523	427677	604953	607	395047	032630	85	967370	4
57	572636	522	427364	605317	607	394683	032681	85	967319	3
58	572950	522	427050	605682	607	394318	032732	85	967268	2
59	573263	521	426737	606046	606	393954	032783	85	967217	1
60	573575		426425	606410		393590	032834		967166	0
′	Cosine.		Secant.	Cotang.		Tang.	Cosec.		Sine.	′

(22°) Logarithmic Sines.

′	Sine.	D.	Cosec.	Tang.	D.	Cotang.	Secant.	D.	Cosine.	
0	9.573575	521	10.426425	9.606410	606	10.393590	10.032834	85	9.967166	60
1	573888	520	426112	606773	606	393227	032885	85	967115	59
2	574200	520	425800	607137	605	392863	032936	85	967064	58
3	574512	519	425488	607500	605	392500	032987	85	967013	57
4	574824	519	425176	607863	604	392137	033039	85	966961	56
5	575136	519	424864	608225	604	391775	033090	85	966910	55
6	575447	518	424553	608588	604	391412	033141	85	966859	54
7	575758	518	424242	608950	603	391050	033192	85	966808	53
8	576069	517	423931	609312	603	390688	033244	86	966756	52
9	576379	517	423621	609674	603	390326	033295	86	966705	51
10	576689	516	423311	610036	602	389964	033347	86	966653	50
11	9.576999	516	10.423001	9.610397	602	10.389603	10.033398	86	9.966602	49
12	577309	516	422691	610759	602	389241	033450	86	966550	48
13	577618	515	422382	611120	601	388880	033501	86	966499	47
14	577927	515	422073	611480	601	388520	033553	86	966447	46
15	578236	514	421764	611841	601	388159	033605	86	966395	45
16	578545	514	421455	612201	600	387799	033656	86	966344	44
17	578853	513	421147	612561	600	387439	033708	86	966292	43
18	579162	513	420838	612921	600	387079	033760	86	966240	42
19	579470	513	420530	613281	599	386719	033812	86	966188	41
20	579777	512	420223	613641	599	386359	033864	86	966136	40
21	9.580085	512	10.419915	9.614000	598	10.386000	10.033915	87	9.966085	39
22	580392	511	419608	614359	598	385641	033967	87	966033	38
23	580699	511	419301	614718	598	385282	034019	87	965981	37
24	581005	511	418995	615077	597	384923	034072	87	965928	36
25	581312	510	418688	615435	597	384565	034124	87	965876	35
26	581618	510	418382	615793	597	384207	034176	87	965824	34
27	581924	509	418076	616151	596	383849	034228	87	965772	33
28	582229	509	417771	616509	596	383491	034280	87	965720	32
29	582535	509	417465	616867	596	383133	034332	87	965668	31
30	582840	508	417160	617224	595	382776	034385	87	965615	30
31	9.583145	508	10.416855	9.617582	595	10.382418	10.034437	87	9.965563	29
32	583449	507	416551	617939	595	382061	034489	87	965511	28
33	583754	507	416246	618295	594	381705	034542	87	965458	27
34	584058	506	415942	618652	594	381348	034594	87	965406	26
35	584361	506	415639	619008	594	380992	034647	88	965353	25
36	584665	506	415335	619364	593	380636	034699	88	965301	24
37	584968	505	415032	619721	593	380279	034752	88	965248	23
38	585272	505	414728	620076	593	379924	034805	88	965195	22
39	585574	504	414426	620432	592	379568	034857	88	965143	21
40	585877	504	414123	620787	592	379213	034910	88	965090	20
41	9.586179	503	10.413821	9.621142	592	10.378858	10.034963	88	9.965037	19
42	586482	503	413518	621497	591	378503	035016	88	964984	18
43	586783	503	413217	621852	591	378148	035069	88	964931	17
44	587085	502	412915	622207	590	377793	035121	88	964879	16
45	587386	502	412614	622561	590	377439	035174	88	964826	15
46	587688	501	412312	622915	590	377085	035227	88	964773	14
47	587989	501	412011	623269	589	376731	035281	88	964719	13
48	588289	501	411711	623623	589	376377	035334	89	964666	12
49	588590	500	411410	623976	589	376024	035387	89	964613	11
50	588890	500	411110	624330	588	375670	035440	89	964560	10
51	9.589190	499	10.410810	9.624683	588	10.375317	10.035493	89	9.964507	9
52	589489	499	410511	625036	588	374964	035546	89	964454	8
53	589789	499	410211	625388	587	374612	035600	89	964400	7
54	590088	498	409912	625741	587	374259	035653	89	964347	6
55	590387	498	409613	626093	587	373907	035706	89	964294	5
56	590686	497	409314	626445	586	373555	035760	89	964240	4
57	590984	497	409016	626797	586	373203	035813	89	964187	3
58	591282	497	408718	627149	586	372851	035867	89	964133	2
59	591580	496	408420	627501	585	372499	035920	89	964080	1
60	591878		408122	627852		372148	035974		964026	0
	Cosine.		Secant.	Cotang.		Tang.	Cosec.		Sine.	′

Tangents and Secants. (23°)

/	Sine.	D.	Cosec.	Tang.	D.	Cotang.	Secant.	D.	Cosine.	
0	9.591878	496	10.408122	9.627852	585	10.372148	10.035974	89	9.964026	60
1	592176	495	407824	628203	585	371797	036028	89	963972	59
2	592473	495	407527	628554	585	371446	036081	89	963919	58
3	592770	495	407230	628905	584	371095	036135	90	963865	57
4	593067	494	406933	629255	584	370745	036189	90	963811	56
5	593363	494	406637	629606	583	370394	036243	90	963757	55
6	593659	493	406341	629956	583	370044	036296	90	963704	54
7	593955	493	406045	630306	583	369694	036350	90	963650	53
8	594251	493	405749	630656	583	369344	036404	90	963596	52
9	594547	492	405453	631005	582	368995	036458	90	963542	51
10	594842	492	405158	631355	582	368645	036512	90	963488	50
11	9.595137	491	10.404863	9.631704	582	10.368296	10.036566	90	9.963434	49
12	595432	491	404568	632053	581	367947	036621	90	963379	48
13	595727	491	404273	632401	581	367599	036675	90	963325	47
14	596021	490	403979	632750	581	367250	036729	90	963271	46
15	596315	490	403685	633098	580	366902	036783	90	963217	45
16	596609	489	403391	633447	580	366553	036837	90	963163	44
17	596903	489	403097	633795	580	366205	036892	91	963108	43
18	597196	489	402804	634143	579	365857	036946	91	963054	42
19	597490	488	402510	634490	579	365510	037001	91	962999	41
20	597783	488	402217	634838	579	365162	037055	91	962945	40
21	9.598075	487	10.401925	9.635185	578	10.364815	10.037110	91	9.962890	39
22	598368	487	401632	635532	578	364468	037164	91	962836	38
23	598660	487	401340	635879	578	364121	037219	91	962781	37
24	598952	486	401048	636226	577	363774	037273	91	962727	36
25	599244	486	400756	636572	577	363428	037328	91	962672	35
26	599536	485	400464	636919	577	363081	037383	91	962617	34
27	599827	485	400173	637265	577	362735	037438	91	962562	33
28	600118	485	399882	637611	576	362389	037492	91	962508	32
29	600409	484	399591	637956	576	362044	037547	91	962453	31
30	600700	484	399300	638302	576	361698	037602	92	962398	30
31	9.600990	484	10.399010	9.638647	575	10.361353	10.037657	92	9.962343	29
32	601280	483	398720	638992	575	361008	037712	92	962288	28
33	601570	483	398430	639337	575	360663	037767	92	962233	27
34	601860	482	398140	639682	574	360318	037822	92	962178	26
35	602150	482	397850	640027	574	359973	037877	92	962123	25
36	602439	482	397561	640371	574	359629	037933	92	962067	24
37	602728	481	397272	640716	573	359284	037988	92	962012	23
38	603017	481	396983	641060	573	358940	038043	92	961957	22
39	603305	481	396695	641404	573	358596	038098	92	961902	21
40	603594	480	396406	641747	572	358253	038154	92	961846	20
41	9.603882	480	10.396118	9.642091	572	10.357909	10.038209	92	9.961791	19
42	604170	479	395830	642434	572	357566	038265	92	961735	18
43	604457	479	395543	642777	572	357223	038320	92	961680	17
44	604745	479	395255	643120	571	356880	038376	93	961624	16
45	605032	478	394968	643463	571	356537	038431	93	961569	15
46	605319	478	394681	643806	571	356194	038487	93	961513	14
47	605606	478	394394	644148	570	355852	038542	93	961458	13
48	605892	477	394108	644490	570	355510	038598	93	961402	12
49	606179	477	393821	644832	570	355168	038654	93	961346	11
50	606465	476	393535	645174	569	354826	038710	93	961290	10
51	9.606751	476	10.393249	9.645516	569	10.354484	10.038765	93	9.961235	9
52	607036	476	392964	645857	569	354143	038821	93	961179	8
53	607322	475	392678	646199	569	353801	038877	93	961123	7
54	607607	475	392393	646540	568	353460	038933	93	961067	6
55	607892	474	392108	646881	568	353119	038989	93	961011	5
56	608177	474	391823	647222	568	352778	039045	93	960955	4
57	608461	474	391539	647562	567	352438	039101	93	960899	3
58	608745	473	391255	647903	567	352097	039157	94	960843	2
59	609029	473	390971	648243	567	351757	039214	94	960786	1
60	609313		390687	648583		351417	039270		960730	0
	Cosine.		Secant.	Cotang.		Tang.	Cosec.		Sine.	/

(24°) Logarithmic Sines.

/	Sine.	D.	Cosec.	Tang.	D.	Cotang.	Secant.	D.	Cosine.	
0	9.609313	473	10.390687	9.648583	566	10.351417	10.039270	94	9.960730	60
1	609597	472	390403	648923	566	351077	039326	94	960674	59
2	609880	472	390120	649263	566	350737	039382	94	960618	58
3	610164	472	389836	649602	566	350398	039439	94	960561	57
4	610447	471	389553	649942	565	350058	039495	94	960505	56
5	610729	471	389271	650281	565	349719	039552	94	960448	55
6	611012	470	388988	650620	565	349380	039608	94	960392	54
7	611294	470	388706	650959	564	349041	039665	94	960335	53
8	611576	470	388424	651297	564	348703	039721	94	960279	52
9	611858	469	388142	651636	564	348364	039778	94	960222	51
10	612140	469	387860	651974	563	348026	039835	94	960165	50
11	9.612421	469	10.387579	9.652312	563	10.347688	10.039891	95	9.960109	49
12	612702	468	387298	652650	563	347350	039948	95	960052	48
13	612983	468	387017	652988	563	347012	040005	95	959995	47
14	613264	467	386736	653326	562	346674	040062	95	959938	46
15	613545	467	386455	653663	562	346337	040118	95	959882	45
16	613825	467	386175	654000	562	346000	040175	95	959825	44
17	614105	466	385895	654337	561	345663	040232	95	959768	43
18	614385	466	385615	654674	561	345326	040289	95	959711	42
19	614665	466	385335	655011	561	344989	040346	95	959654	41
20	614944	465	385056	655348	561	344652	040404	95	959596	40
21	9.615223	465	10.384777	9.655684	560	10.344316	10.040461	95	9.959539	39
22	615502	465	384498	656020	560	343980	040518	95	959482	38
23	615781	464	384219	656356	560	343644	040575	95	959425	37
24	616060	464	383940	656692	559	343308	040632	95	959368	36
25	616338	464	383662	657028	559	342972	040690	95	959310	35
26	616616	463	383384	657364	559	342636	040747	96	959253	34
27	616894	463	383106	657699	559	342301	040805	96	959195	33
28	617172	462	382828	658034	558	341966	040862	96	959138	32
29	617450	462	382550	658369	558	341631	040919	96	959081	31
30	617727	462	382273	658704	558	341296	040977	96	959023	30
31	9.618004	461	10.381996	9.659039	558	10.340961	10.041035	96	9.958965	29
32	618281	461	381719	659373	557	340627	041092	96	958908	28
33	618558	461	381442	659708	557	340292	041150	96	958850	27
34	618834	460	381166	660042	557	339958	041208	96	958792	26
35	619110	460	380890	660376	557	339624	041266	96	958734	25
36	619386	460	380614	660710	556	339290	041323	96	958677	24
37	619662	459	380338	661043	556	338957	041381	96	958619	23
38	619938	459	380062	661377	556	338623	041439	96	958561	22
39	620213	459	379787	661710	555	338290	041497	97	958503	21
40	620488	458	379512	662043	555	337957	041555	97	958445	20
41	9.620763	458	10.379237	9.662376	555	10.337624	10.041613	97	9.958387	19
42	621038	457	378962	662709	554	337291	041671	97	958329	18
43	621313	457	378687	663042	554	336958	041729	97	958271	17
44	621587	457	378413	663375	554	336625	041787	97	958213	16
45	621861	456	378139	663707	554	336293	041846	97	958154	15
46	622135	456	377865	664039	553	335961	041904	97	958096	14
47	622409	456	377591	664371	553	335629	041962	97	958038	13
48	622682	455	377318	664703	553	335297	042021	97	957979	12
49	622956	455	377044	665035	553	334965	042079	97	957921	11
50	623229	455	376771	665366	552	334634	042137	97	957863	10
51	9.623502	454	10.376498	9.665697	552	10.334303	10.042196	97	9.957804	9
52	623774	454	376226	666029	552	333971	042254	98	957746	8
53	624047	454	375953	666360	551	333640	042313	98	957687	7
54	624319	453	375681	666691	551	333309	042372	98	957628	6
55	624591	453	375409	667021	551	332979	042430	98	957570	5
56	624863	453	375137	667352	551	332648	042489	98	957511	4
57	625135	452	374865	667682	550	332318	042548	98	957452	3
58	625406	452	374594	668013	550	331987	042607	98	957393	2
59	625677	452	374323	668343	550	331657	042665	98	957335	1
60	625948	452	374052	668672	550	331328	042724	98	957276	0
	Cosine.		Secant.	Cotang.		Tang.	Cosec.		Sine.	/

Tangents and Secants. (25°)

′	Sine.	D.	Cosec.	Tang.	D.	Cotang.	Secant.	D.	Cosine.	
0	9.625948	451	10.374052	9.668673	550	10.331327	10.042724	98	9.957276	60
1	626219	451	373781	669002	549	330998	042783	98	957217	59
2	626490	451	373510	669332	549	330668	042842	98	957158	58
3	626760	450	373240	669661	549	330339	042901	98	957099	57
4	627030	450	372970	669991	548	330009	042960	98	957040	56
5	627300	450	372700	670320	548	329680	043019	98	956981	55
6	627570	449	372430	670649	548	329351	043079	99	956921	54
7	627840	449	372160	670977	548	329023	043138	99	956862	53
8	628109	449	371891	671306	547	328694	043197	99	956803	52
9	628378	448	371622	671634	547	328366	043256	99	956744	51
10	628647	448	371353	671963	547	328037	043316	99	956684	50
11	9.628916	447	10.371084	9.672291	547	10.327709	10.043375	99	9.956625	49
12	629185	447	370815	672619	546	327381	043434	99	956566	48
13	629453	447	370547	672947	546	327053	043494	99	956506	47
14	629721	446	370279	673274	546	326726	043553	99	956447	46
15	629989	446	370011	673602	546	326398	043613	99	956387	45
16	630257	446	369743	673929	545	326071	043673	99	956327	44
17	630524	446	369476	674257	545	325743	043732	99	956268	43
18	630792	445	369208	674584	545	325416	043792	100	956208	42
19	631059	445	368941	674910	544	325090	043852	100	956148	41
20	631326	445	368674	675237	544	324763	043911	100	956089	40
21	9.631593	444	10.368407	9.675564	544	10.324436	10.043971	100	9.956029	39
22	631859	444	368141	675890	544	324110	044031	100	955969	38
23	632125	444	367875	676216	543	323784	044091	100	955909	37
24	632392	443	367608	676543	543	323457	044151	100	955849	36
25	632658	443	367342	676869	543	323131	044211	100	955789	35
26	632923	443	367077	677194	543	322806	044271	100	955729	34
27	633189	442	366811	677520	542	322480	044331	100	955669	33
28	633454	442	366546	677846	542	322154	044391	100	955609	32
29	633719	442	366281	678171	542	321829	044452	100	955548	31
30	633984	441	366016	678496	542	321504	044512	100	955488	30
31	9.634249	441	10.365751	9.678821	541	10.321179	10.044572	101	9.955428	29
32	634514	440	365486	679146	541	320854	044632	101	955368	28
33	634778	440	365222	679471	541	320529	044693	101	955307	27
34	635042	440	364958	679795	541	320205	044753	101	955247	26
35	635306	439	364694	680120	540	319880	044814	101	955186	25
36	635570	439	364430	680444	540	319556	044874	101	955126	24
37	635834	439	364166	680768	540	319232	044935	101	955065	23
38	636097	438	363903	681092	540	318908	044995	101	955005	22
39	636360	438	363640	681416	539	318584	045056	101	954944	21
40	636623	438	363377	681740	539	318260	045117	101	954883	20
41	9.636886	437	10.363114	9.682063	539	10.317937	10.045177	101	9.954823	19
42	637148	437	362852	682387	539	317613	045238	101	954762	18
43	637411	437	362589	682710	538	317290	045299	101	954701	17
44	637673	437	362327	683033	538	316967	045360	101	954640	16
45	637935	436	362065	683356	538	316644	045421	101	954579	15
46	638197	436	361803	683679	538	316321	045482	102	954518	14
47	638458	436	361542	684001	537	315999	045543	102	954457	13
48	638720	435	361280	684324	537	315676	045604	102	954396	12
49	638981	435	361019	684646	537	315354	045665	102	954335	11
50	639242	435	360758	684968	537	315032	045726	102	954274	10
51	9.639503	434	10.360497	9.685290	536	10.314710	10.045787	102	9.954213	9
52	639764	434	360236	685612	536	314388	045848	102	954152	8
53	640024	434	359976	685934	536	314066	045910	102	954090	7
54	640284	433	359716	686255	536	313745	045971	102	954029	6
55	640544	433	359456	686577	535	313423	046032	102	953968	5
56	640804	433	359196	686898	535	313102	046094	102	953906	4
57	641064	432	358936	687219	535	312781	046155	102	953845	3
58	641324	432	358676	687540	535	312460	046217	102	953783	2
59	641584	432	358416	687861	534	312139	046278	103	953722	1
60	641842		358158	688182		311818	046340		953660	0
	Cosine.		Secant.	Cotang.		Tang.	Cosec.		Sine.	′

(26°) Logarithmic Sines.

′	Sine.	D.	Cosec.	Tang.	D.	Cotang.	Secant.	D.	Cosine.	
0	9.641842	431	10.358158	9.688182	534	10.311818	10.046340	103	9.953660	60
1	642101	431	357899	688502	534	311498	046401	103	953599	59
2	642360	431	357640	688823	534	311177	046463	103	953537	58
3	642618	430	357382	689143	533	310857	046525	103	953475	57
4	642877	430	357123	689463	533	310537	046587	103	953413	56
5	643135	430	356865	689783	533	310217	046648	102	953352	55
6	643393	430	356607	690103	533	309897	046710	103	953290	54
7	643650	429	356350	690423	533	309577	046772	103	953228	53
8	643908	429	356092	690742	532	309258	046834	103	953166	52
9	644165	429	355835	691062	532	308938	046896	103	953104	51
10	644423	428	355577	691381	532	308619	046958	103	953042	50
11	9.644680	428	10.355320	9.691700	531	10.308300	10.047020	104	9.952980	49
12	644936	428	355064	692019	531	307981	047082	104	952918	48
13	645193	427	354807	692338	531	307662	047145	104	952855	47
14	645450	427	354550	692656	531	307344	047207	104	952793	46
15	645706	427	354294	692975	531	307025	047269	104	952731	45
16	645962	426	354038	693293	530	306707	047331	104	952669	44
17	646218	426	353782	693612	530	306388	047394	104	952606	43
18	646474	426	353526	693930	530	306070	047456	104	952544	42
19	646729	425	353271	694248	530	305752	047519	104	952481	41
20	646984	425	353016	694566	529	305434	047581	104	952419	40
21	9.647240	425	10.352760	9.694883	529	10.305117	10.047644	104	9.952356	39
22	647494	424	352506	695201	529	304799	047706	104	952294	38
23	647749	424	352251	695518	529	304482	047769	104	952231	37
24	648004	424	351996	695836	529	304164	047832	104	952168	36
25	648258	424	351742	696153	528	303847	047894	105	952106	35
26	648512	423	351488	696470	528	303530	047957	105	952043	34
27	648766	423	351234	696787	528	303213	048020	105	951980	33
28	649020	423	350980	697103	528	302897	048083	105	951917	32
29	649274	422	350726	697420	527	302580	048146	105	951854	31
30	649527	422	350473	697736	527	302264	048209	105	951791	30
31	9.649781	422	10.350219	9.698053	527	10.301947	10.048272	105	9.951728	29
32	650034	422	349966	698369	527	301631	048335	105	951665	28
33	650287	421	349713	698685	526	301315	048398	105	951602	27
34	650539	421	349461	699001	526	300999	048461	105	951539	26
35	650792	421	349208	699316	526	300684	048524	105	951476	25
36	651044	420	348956	699632	526	300368	048588	105	951412	24
37	651297	420	348703	699947	526	300053	048651	106	951349	23
38	651549	420	348451	700263	525	299737	048714	106	951286	22
39	651800	419	348200	700578	525	299422	048778	106	951222	21
40	652052	419	347948	700893	525	299107	048841	106	951159	20
41	9.652304	419	10.347696	9.701208	524	10.298792	10.048904	106	9.951096	19
42	652555	418	347445	701523	524	298477	048968	106	951032	18
43	652806	418	347194	701837	524	298163	049032	106	950968	17
44	653057	418	346943	702152	524	297848	049095	106	950905	16
45	653308	418	346692	702466	524	297534	049159	106	950841	15
46	653558	417	346442	702780	523	297220	049222	106	950778	14
47	653808	417	346192	703095	523	296905	049286	106	950714	13
48	654059	417	345941	703409	523	296591	049350	106	950650	12
49	654309	416	345691	703723	523	296277	049414	106	950586	11
50	654558	416	345442	704036	522	295964	049478	107	950522	10
51	9.654808	416	10.345192	9.704350	522	10.295650	10.049542	107	9.950458	9
52	655058	416	344942	704663	522	295337	049606	107	950394	8
53	655307	415	344693	704977	522	295023	049670	107	950330	7
54	655556	415	344444	705290	522	294710	049734	107	950266	6
55	655805	415	344195	705603	521	294397	049798	107	950202	5
56	656054	414	343946	705916	521	294084	049862	107	950138	4
57	656302	414	343698	706228	521	293772	049926	107	950074	3
58	656551	414	343449	706541	521	293459	049990	107	950010	2
59	656799	414	343201	706854	521	293146	050055	107	949945	1
60	657047	413	342953	707166	521	292834	050119	107	949881	0
	Cosine.		Secant.	Cotang.		Tang.	Cosec.		Sine.	′

Tangents and Secants. (27°)

/	Sine.	D.	Cosec.	Tang.	D.	Cotang.	Secant.	D.	Cosine.	
0	9.657047	413	10.342953	9.707166	520	10.292834	10.050119	107	9.949881	60
1	657295	413	342705	707478	520	292522	050184	107	949816	59
2	657542	412	342458	707790	520	292210	050248	107	949752	58
3	657790	412	342210	708102	520	291898	050312	108	949688	57
4	658037	412	341963	708414	519	291586	050377	108	949623	56
5	658284	412	341716	708726	519	291274	050442	108	949558	55
6	658531	411	341469	709037	519	290963	050506	108	949494	54
7	658778	411	341222	709349	519	290651	050571	108	949429	53
8	659025	411	340975	709660	519	290340	050636	108	949364	52
9	659271	410	340729	709971	518	290029	050700	108	949300	51
10	659517	410	340483	710282	518	289718	050765	108	949235	50
11	9.659763	410	10.340237	9.710593	518	10.289407	10.050830	108	9.949170	49
12	660009	409	339991	710904	518	289096	050895	108	949105	48
13	660255	409	339745	711215	518	288785	050960	108	949040	47
14	660501	409	339499	711525	517	288475	051025	108	948975	46
15	660746	409	339254	711836	517	288164	051090	108	948910	45
16	660991	408	339009	712146	517	287854	051155	108	948845	44
17	661236	408	338764	712456	517	287544	051220	109	948780	43
18	661481	408	338519	712766	516	287234	051285	109	948715	42
19	661726	407	338274	713076	516	286924	051350	109	948650	41
20	661970	407	338030	713386	516	286614	051416	109	948584	40
21	9.662214	407	10.337786	9.713696	516	10.286304	10.051481	109	9.948519	39
22	662459	407	337541	714005	516	285995	051546	109	948454	38
23	662703	406	337297	714314	515	285686	051612	109	948388	37
24	662946	406	337054	714624	515	285376	051677	109	948323	36
25	663190	406	336810	714933	515	285067	051743	109	948257	35
26	663433	405	336567	715242	515	284758	051808	109	948192	34
27	663677	405	336323	715551	514	284449	051874	109	948126	33
28	663920	405	336080	715860	514	284140	051940	109	948060	32
29	664163	405	335837	716168	514	283832	052005	110	947995	31
30	664406	404	335594	716477	514	283523	052071	110	947929	30
31	9.664648	404	10.335352	9.716785	514	10.283215	10.052137	110	9.947863	29
32	664891	404	335109	717093	513	282907	052203	110	947797	28
33	665133	403	334867	717401	513	282599	052269	110	947731	27
34	665375	403	334625	717709	513	282291	052335	110	947665	26
35	665617	403	334383	718017	513	281983	052400	110	947600	25
36	665859	402	334141	718325	513	281675	052467	110	947533	24
37	666100	402	333900	718633	513	281367	052533	110	947467	23
38	666342	402	333658	718940	512	281060	052599	110	947401	22
39	666583	402	333417	719248	512	280752	052665	110	947335	21
40	666824	401	333176	719555	512	280445	052731	110	947269	20
41	9.667065	401	10.332935	9.719862	512	10.280138	10.052797	110	9.947203	19
42	667305	401	332695	720169	511	279831	052864	111	947136	18
43	667546	401	332454	720476	511	279524	052930	111	947070	17
44	667786	400	332214	720783	511	279217	052996	111	947004	16
45	668027	400	331973	721089	511	278911	053063	111	946937	15
46	668267	400	331733	721396	511	278604	053129	111	946871	14
47	668506	399	331494	721702	510	278298	053196	111	946804	13
48	668746	399	331254	722009	510	277991	053262	111	946738	12
49	668986	399	331014	722315	510	277685	053329	111	946671	11
50	669225	399	330775	722621	510	277379	053396	111	946604	10
51	9.669464	398	10.330536	9.722927	510	10.277073	10.053462	111	9.946538	9
52	669703	398	330297	723232	509	276768	053529	111	946471	8
53	669942	398	330058	723538	509	276462	053596	111	946404	7
54	670181	397	329819	723844	509	276156	053663	111	946337	6
55	670419	397	329581	724149	509	275851	053730	112	946270	5
56	670658	397	329342	724454	509	275546	053797	112	946203	4
57	670896	397	329104	724759	508	275241	053864	112	946136	3
58	671134	396	328866	725065	508	274935	053931	112	946069	2
59	671372	396	328628	725369	508	274631	053998	112	946002	1
60	671609		328391	725674		274326	054065		945935	0
	Cosine.		Secant.	Cotang.		Tang.	Cosec.		Sine.	/

TABLE VI.

(28°) Logarithmic Sines.

′	Sine.	D.	Cosec.	Tang.	D.	Cotang.	Secant.	D.	Cosine.	
0	9.671609	396	10.328391	9.725674	508	10.274326	10.054065	112	9.945935	60
1	671847	395	328153	725979	508	274021	054132	112	945868	59
2	672084	395	327916	726284	507	273716	054200	112	945800	58
3	672321	395	327679	726588	507	273412	054267	112	945733	57
4	672558	395	327442	726892	507	273108	054334	112	945666	56
5	672795	394	327205	727197	507	272803	054402	112	945598	55
6	673032	394	326968	727501	507	272499	054469	112	945531	54
7	673268	394	326732	727805	506	272195	054536	113	945464	53
8	673505	394	326495	728109	506	271891	054604	113	945396	52
9	673741	393	326259	728412	506	271588	054672	113	945328	51
10	673977	393	326023	728716	506	271284	054739	113	945261	50
11	9.674213	393	10.325787	9.729020	506	10.270980	10.054807	113	9.945193	49
12	674448	392	325552	729323	505	270677	054875	113	945125	48
13	674684	392	325316	729626	505	270374	054942	113	945058	47
14	674919	392	325081	729929	505	270071	055010	113	944990	46
15	675155	392	324845	730233	505	269767	055078	113	944922	45
16	675390	391	324610	730535	505	269465	055146	113	944854	44
17	675624	391	324376	730838	504	269162	055214	113	944786	43
18	675859	391	324141	731141	504	268859	055282	113	944718	42
19	676094	391	323906	731444	504	268556	055350	113	944650	41
20	676328	390	323672	731746	504	268254	055418	114	944582	40
21	9.676562	390	10.323438	9.732048	504	10.267952	10.055486	114	9.944514	39
22	676796	390	323204	732351	503	267649	055554	114	944446	38
23	677030	390	322970	732653	503	267347	055623	114	944377	37
24	677264	389	322736	732955	503	267045	055691	114	944309	36
25	677498	389	322502	733257	503	266743	055759	114	944241	35
26	677731	389	322269	733558	503	266442	055828	114	944172	34
27	677964	388	322036	733860	502	266140	055896	114	944104	33
28	678197	388	321803	734162	502	265838	055964	114	944036	32
29	678430	388	321570	734463	502	265537	056033	114	943967	31
30	678663	388	321337	734764	502	265236	056101	114	943899	30
31	9.678895	387	10.321105	9.735066	502	10.264934	10.056170	114	9.943830	29
32	679128	387	320872	735367	502	264633	056239	114	943761	28
33	679360	387	320640	735668	501	264332	056307	115	943693	27
34	679592	387	320408	735969	501	264031	056376	115	943624	26
35	679824	386	320176	736269	501	263731	056445	115	943555	25
36	680056	386	319944	736570	501	263430	056514	115	943486	24
37	680288	386	319712	736871	501	263129	056583	115	943417	23
38	680519	385	319481	737171	500	262829	056652	115	943348	22
39	680750	385	319250	737471	500	262529	056721	115	943279	21
40	680982	385	319018	737771	500	262229	056790	115	943210	20
41	9.681213	385	10.318787	9.738071	500	10.261929	10.056859	115	9.943141	19
42	681443	384	318557	738371	500	261629	056928	115	943072	18
43	681674	384	318326	738671	499	261329	056997	115	943003	17
44	681905	384	318095	738971	499	261029	057066	115	942934	16
45	682135	384	317865	739271	499	260729	057136	115	942864	15
46	682365	383	317635	739570	499	260430	057205	116	942795	14
47	682595	383	317405	739870	499	260130	057274	116	942726	13
48	682825	383	317175	740169	499	259831	057344	116	942656	12
49	683055	383	316945	740468	498	259532	057413	116	942587	11
50	683284	382	316716	740767	498	259233	057483	116	942517	10
51	9.683514	382	10.316486	9.741066	498	10.258934	10.057552	116	9.942448	9
52	683743	382	316257	741365	498	258635	057622	116	942378	8
53	683972	382	316028	741664	498	258336	057692	116	942308	7
54	684201	381	315799	741962	497	258038	057761	116	942239	6
55	684430	381	315570	742261	497	257739	057831	116	942169	5
56	684658	381	315342	742559	497	257441	057901	116	942099	4
57	684887	380	315113	742858	497	257142	057971	116	942029	3
58	685115	380	314885	743156	497	256844	058041	116	941959	2
59	685343	380	314657	743454	497	256546	058111	117	941889	1
60	685571		314429	743752		256248	058181		941819	0
	Cosine.		Secant.	Cotang.		Tang.	Cosec.		Sine	′

Tangents and Secants. (29°)

′	Sine.	D.	Cosec.	Tang.	D.	Cotang.	Secant.	D.	Cosine.	
0	9.685572	380	10.314429	9.743752	496	10.256248	10.058181	117	9.941819	60
1	685799	379	314201	744050	496	255950	058251	117	941749	59
2	686027	379	313973	744348	496	255652	058321	117	941679	58
3	686254	379	313746	744645	496	255355	058391	117	941609	57
4	686482	379	313518	744943	496	255057	058461	117	941539	56
5	686709	378	313291	745240	495	254760	058531	117	941469	55
6	686936	378	313064	745538	495	254462	058602	117	941398	54
7	687163	378	312837	745835	495	254165	058672	117	941328	53
8	687389	378	312611	746132	495	253868	058742	117	941258	52
9	687616	377	312384	746429	495	253571	058813	117	941187	51
10	687843	377	312157	746726	495	253274	058883	117	941117	50
11	9.688069	377	10.311931	9.747023	494	10.252977	10.058954	118	9.941046	49
12	688295	377	311705	747319	494	252681	059025	118	940975	48
13	688521	376	311479	747616	494	252384	059095	118	940905	47
14	688747	376	311253	747913	494	252087	059166	118	940834	46
15	688972	376	311028	748209	494	251791	059237	118	940763	45
16	689198	376	310802	748505	493	251495	059307	118	940693	44
17	689423	375	310577	748801	493	251199	059378	118	940622	43
18	689648	375	310352	749097	493	250903	059449	118	940551	42
19	689873	375	310127	749393	493	250607	059520	118	940480	41
20	690098	375	309902	749689	493	250311	059591	118	940409	40
21	9.690323	374	10.309677	9.749985	493	10.250015	10.059662	118	9.940338	39
22	690548	374	309452	750281	492	249719	059733	118	940267	38
23	690772	374	309228	750576	492	249424	059804	118	940196	37
24	690996	374	309004	750872	492	249128	059875	119	940125	36
25	691220	373	308780	751167	492	248833	059946	119	940054	35
26	691444	373	308556	751462	492	248538	060018	119	939982	34
27	691668	373	308332	751757	492	248243	060089	119	939911	33
28	691892	373	308108	752052	491	247948	060160	119	939840	32
29	692115	372	307885	752347	491	247653	060232	119	939768	31
30	692339	372	307661	752642	491	247358	060303	119	939697	30
31	9.692562	372	10.307438	9.752937	491	10.247063	10.060375	119	9.939625	29
32	692785	371	307215	753231	491	246769	060446	119	939554	28
33	693008	371	306992	753526	491	246474	060518	119	939482	27
34	693231	371	306769	753820	490	246180	060590	119	939410	26
35	693453	371	306547	754115	490	245885	060661	119	939339	25
36	693676	370	306324	754409	490	245591	060733	119	939267	24
37	693898	370	306102	754703	490	245297	060805	120	939195	23
38	694120	370	305880	754997	490	245003	060877	120	939123	22
39	694342	370	305658	755291	490	244709	060948	120	939052	21
40	694564	369	305436	755585	489	244415	061020	120	938980	20
41	9.694786	369	10.305214	9.755878	489	10.244122	10.061092	120	9.938908	19
42	695007	369	304993	756172	489	243828	061164	120	938836	18
43	695229	369	304771	756465	489	243535	061237	120	938763	17
44	695450	368	304550	756759	489	243241	061309	120	938691	16
45	695671	368	304329	757052	489	242948	061381	120	938619	15
46	695892	368	304108	757345	488	242655	061453	120	938547	14
47	696113	368	303887	757638	488	242362	061525	120	938475	13
48	696334	367	303666	757931	488	242069	061598	121	938402	12
49	696554	367	303446	758224	488	241776	061670	121	938330	11
50	696775	367	303225	758517	488	241483	061742	121	938258	10
51	9.696995	367	10.303005	9.758810	488	10.241190	10.061815	121	9.938185	9
52	697215	366	302785	759102	487	240898	061887	121	938113	8
53	697435	366	302565	759395	487	240605	061960	121	938040	7
54	697654	366	302346	759687	487	240313	062033	121	937967	6
55	697874	366	302126	759979	487	240021	062105	121	937895	5
56	698094	365	301906	760272	487	239728	062178	121	937822	4
57	698313	365	301687	760564	487	239436	062251	121	937749	3
58	698532	365	301468	760856	486	239144	062324	121	937676	2
59	698751	365	301249	761148	486	238852	062396	121	937604	1
60	698970		301030	761439		238561	062469		937531	0
	Cosine.		Secant	Cotang.		Tang.	Cosec.		Sine.	′

TABLE VI.

(30°) Logarithmic Sines.

′	Sine.	D.	Cosec.	Tang.	D.	Cotang.	Secant.	D.	Cosine.	
0	9.698970	364	10.301030	9.761439	486	10.238561	10.062469	121	9.937531	60
1	699189	364	300811	761731	486	238269	062542	122	937458	59
2	699407	364	300593	762023	486	237977	062615	122	937385	58
3	699626	364	300374	762314	486	237686	062688	122	937312	57
4	699844	363	300156	762606	485	237394	062762	122	937238	56
5	700062	363	299938	762897	485	237103	062835	122	937165	55
6	700280	363	299720	763188	485	236812	062908	122	937092	54
7	700498	363	299502	763479	485	236521	062981	122	937019	53
8	700716	363	299284	763770	485	236230	063054	122	936946	52
9	700933	362	299067	764061	485	235939	063128	122	936872	51
10	701151	362	298849	764352	484	235648	063201	122	936799	50
11	9.701368	362	10.298632	9.764643	484	10.235357	10.063275	122	9.936725	49
12	701585	362	298415	764933	484	235067	063348	123	936652	48
13	701802	361	298198	765224	484	234776	063422	123	936578	47
14	702019	361	297981	765514	484	234486	063495	123	936505	46
15	702236	361	297764	765805	484	234195	063569	123	936431	45
16	702452	361	297548	766095	484	233905	063643	123	936357	44
17	702669	360	297331	766385	483	233615	063716	123	936284	43
18	702885	360	297115	766675	483	233325	063790	123	936210	42
19	703101	360	296899	766965	483	233035	063864	123	936136	41
20	703317	360	296683	767255	483	232745	063938	123	936062	40
21	9.703533	359	10.296467	9.767545	483	10.232455	10.064012	123	9.935988	39
22	703749	359	296251	767834	483	232166	064086	123	935914	38
23	703964	359	296036	768124	482	231876	064160	123	935840	37
24	704179	359	295821	768413	482	231587	064234	124	935766	36
25	704395	359	295605	768703	482	231297	064308	124	935692	35
26	704610	358	295390	768992	482	231008	064382	124	935618	34
27	704825	358	295175	769281	482	230719	064457	124	935543	33
28	705040	358	294960	769570	482	230430	064531	124	935469	32
29	705254	358	294746	769860	481	230140	064605	124	935395	31
30	705469	357	294531	770148	481	229852	064680	124	935320	30
31	9.705683	357	10.294317	9.770437	481	10.229563	10.064754	124	9.935246	29
32	705898	357	294102	770726	481	229274	064829	124	935171	28
33	706112	357	293888	771015	481	228985	064903	124	935097	27
34	706326	356	293674	771303	481	228697	064978	124	935022	26
35	706539	356	293461	771592	481	228408	065052	124	934948	25
36	706753	356	293247	771880	480	228120	065127	124	934873	24
37	706967	356	293033	772168	480	227832	065202	124	934798	23
38	707180	355	292820	772457	480	227543	065277	125	934723	22
39	707393	355	292607	772745	480	227255	065351	125	934649	21
40	707606	355	292394	773033	480	226967	065426	125	934574	20
41	9.707819	355	10.292181	9.773321	480	10.226679	10.065501	125	9.934499	19
42	708032	354	291968	773608	479	226392	065576	125	934424	18
43	708245	354	291755	773896	479	226104	065651	125	934349	17
44	708458	354	291542	774184	479	225816	065726	125	934274	16
45	708670	354	291330	774471	479	225529	065801	125	934199	15
46	708882	353	291118	774759	479	225241	065877	125	934123	14
47	709094	353	290906	775046	479	224954	065952	125	934048	13
48	709306	353	290694	775333	479	224667	066027	125	933973	12
49	709518	353	290482	775621	478	224379	066102	125	933898	11
50	709730	353	290270	775908	478	224092	066178	126	933822	10
51	9.709941	352	10.290059	9.776195	478	10.223805	10.066253	126	9.933747	9
52	710153	352	289847	776482	478	223518	066329	126	933671	8
53	710364	352	289636	776769	478	223231	066404	126	933596	7
54	710575	352	289425	777055	478	222945	066480	126	933520	6
55	710786	351	289214	777342	478	222658	066555	126	933445	5
56	710997	351	289003	777628	477	222372	066631	126	933369	4
57	711208	351	288792	777915	477	222085	066707	126	933293	3
58	711419	351	288581	778201	477	221799	066783	126	933217	2
59	711629	350	288371	778487	477	221513	066859	126	933141	1
60	711839		288161	778774		221226	066934		933066	0
	Cosine.		Secant.	Cotang.		Tang.	Cosec.		Sine.	′

Tangents and Secants. (31°)

′	Sine.	D.	Cosec.	Tang.	D.	Cotang.	Secant.	D.	Cosine.	
0	9.711839	350	10.288161	9.778774	477	10.221226	10.066934	126	9.933066	60
1	712050	350	287950	779060	477	220940	067010	127	932990	59
2	712260	350	287740	779346	476	220654	067086	127	932914	58
3	712469	349	287531	779632	476	220368	067162	127	932838	57
4	712679	349	287321	779918	476	220082	067238	127	932762	56
5	712889	349	287111	780203	476	219797	067315	127	932685	55
6	713098	349	286902	780489	476	219511	067391	127	932609	54
7	713308	349	286692	780775	476	219225	067467	127	932533	53
8	713517	348	286483	781060	476	218940	067543	127	932457	52
9	713726	348	286274	781346	475	218654	067620	127	932380	51
10	713935	348	286065	781631	475	218369	067696	127	932304	50
11	9.714144	348	10.285856	9.781916	475	10.218084	10.067772	127	9.932228	49
12	714352	347	285648	782201	475	217799	067849	127	932151	48
13	714561	347	285439	782486	475	217514	067925	128	932075	47
14	714769	347	285231	782771	475	217229	068002	128	931998	46
15	714978	347	285022	783056	475	216944	068079	128	931921	45
16	715186	347	284814	783341	475	216659	068155	128	931845	44
17	715394	346	284606	783626	474	216374	068232	128	931768	43
18	715602	346	284398	783910	474	216090	068309	128	931691	42
19	715809	346	284191	784195	474	215805	068386	128	931614	41
20	716017	346	283983	784479	474	215521	068463	128	931537	40
21	9.716224	345	10.283776	9.784764	474	10.215236	10.068540	128	9.931460	39
22	716432	345	283568	785048	474	214952	068617	128	931383	38
23	716639	345	283361	785332	473	214668	068694	128	931306	37
24	716846	345	283154	785616	473	214384	068771	129	931229	36
25	717053	345	282947	785900	473	214100	068848	129	931152	35
26	717259	344	282741	786184	473	213816	068925	129	931075	34
27	717466	344	282534	786468	473	213532	069002	129	930998	33
28	717673	344	282327	786752	473	213248	069079	129	930921	32
29	717879	344	282121	787036	473	212964	069157	129	930843	31
30	718085	343	281915	787319	472	212681	069234	129	930766	30
31	9.718291	343	10.281709	9.787603	472	10.212397	10.069312	129	9.930688	29
32	718497	343	281503	787886	472	212114	069389	129	930611	28
33	718703	343	281297	788170	472	211830	069467	129	930533	27
34	718909	343	281091	788453	472	211547	069544	129	930456	26
35	719114	342	280886	788736	472	211264	069622	129	930378	25
36	719320	342	280680	789019	472	210981	069700	130	930300	24
37	719525	342	280475	789302	471	210698	069777	130	930223	23
38	719730	342	280270	789585	471	210415	069855	130	930145	22
39	719935	341	280065	789868	471	210132	069933	130	930067	21
40	720140	341	279860	790151	471	209849	070011	130	929989	20
41	9.720345	341	10.279655	9.790433	471	10.209567	10.070089	130	9.929911	19
42	720549	341	279451	790716	471	209284	070167	130	929833	18
43	720754	340	279246	790999	471	209001	070245	130	929755	17
44	720958	340	279042	791281	471	208719	070323	130	929677	16
45	721162	340	278838	791563	470	208437	070401	130	929599	15
46	721366	340	278634	791846	470	208154	070479	130	929521	14
47	721570	340	278430	792128	470	207872	070558	130	929442	13
48	721774	339	278226	792410	470	207590	070636	131	929364	12
49	721978	339	278022	792692	470	207308	070714	131	929286	11
50	722181	339	277819	792974	470	207026	070793	131	929207	10
51	9.722385	339	10.277615	9.793256	470	10.206744	10.070871	131	9.929129	9
52	722588	339	277412	793538	469	206462	070950	131	929050	8
53	722791	338	277209	793819	469	206181	071028	131	928972	7
54	722994	338	277006	794101	469	205899	071107	131	928893	6
55	723197	338	276803	794383	469	205617	071185	131	928815	5
56	723400	338	276600	794664	469	205336	071264	131	928736	4
57	723603	337	276397	794945	469	205055	071343	131	928657	3
58	723805	337	276195	795227	469	204773	071422	131	928578	2
59	724007	337	275993	795508	468	204492	071501	131	928499	1
60	724210	337	275790	795789	468	204211	071580	131	928420	0
	Cosine.		Secant.	Cotang.		Tang.	Cosec.		Sine.	′

(32°) Logarithmic Sines.

′	Sine.	D.	Cosec.	Tang.	D.	Cotang.	Secant.	D.	Cosine.	
0	9.724210	337	10.275790	9.795789	468	10.204211	10.071580	132	9.928420	60
1	724412	337	275588	796070	468	203930	071658	132	928342	59
2	724614	336	275386	796351	468	203649	071737	132	928263	58
3	724816	336	275184	796632	468	203368	071817	132	928183	57
4	725017	336	274983	796913	468	203087	071896	132	928104	56
5	725219	336	274781	797194	468	202806	071975	132	928025	55
6	725420	335	274580	797475	468	202525	072054	132	927946	54
7	725622	335	274378	797755	468	202245	072133	132	927867	53
8	725823	335	274177	798036	467	201964	072213	132	927787	52
9	726024	335	273976	798316	467	201684	072292	132	927708	51
10	726225	335	273775	798596	467	201404	072371	132	927629	50
11	9.726426	334	10.273574	9.798877	467	10.201123	10.072451	132	9.927549	49
12	726626	334	273374	799157	467	200843	072530	133	927470	48
13	726827	334	273173	799437	467	200563	072610	133	927390	47
14	727027	334	272973	799717	467	200283	072690	133	927310	46
15	727228	334	272772	799997	466	200003	072769	133	927231	45
16	727428	333	272572	800277	466	199723	072849	133	927151	44
17	727628	333	272372	800557	466	199443	072929	133	927071	43
18	727828	333	272172	800836	466	199164	073009	133	926991	42
19	728027	333	271973	801116	466	198884	073089	133	926911	41
20	728227	333	271773	801396	466	198604	073169	133	926831	40
21	9.728427	332	10.271573	9.801675	466	10.198325	10.073249	133	9.926751	39
22	728626	332	271374	801955	466	198045	073329	133	926671	38
23	728825	332	271175	802234	465	197766	073409	133	926591	37
24	729024	332	270976	802513	465	197487	073489	133	926511	36
25	729223	331	270777	802792	465	197208	073569	134	926431	35
26	729422	331	270578	803072	465	196928	073649	134	926351	34
27	729621	331	270379	803351	465	196649	073730	134	926270	33
28	729820	331	270180	803630	465	196370	073810	134	926190	32
29	730018	330	269982	803908	465	196092	073890	134	926110	31
30	730216	330	269784	804187	465	195813	073971	134	926029	30
31	9.730415	330	10.269585	9.804466	464	10.195534	10.074051	134	9.925949	29
32	730613	330	269387	804745	464	195255	074132	134	925868	28
33	730811	330	269189	805023	464	194977	074212	134	925788	27
34	731009	329	268991	805302	464	194698	074293	134	925707	26
35	731206	329	268794	805580	464	194420	074374	134	925626	25
36	731404	329	268596	805859	464	194141	074455	135	925545	24
37	731602	329	268398	806137	464	193863	074535	135	925465	23
38	731799	329	268201	806415	463	193585	074616	135	925384	22
39	731996	328	268004	806693	463	193307	074697	135	925303	21
40	732193	328	267807	806971	463	193029	074778	135	925222	20
41	9.732390	328	10.267610	9.807249	463	10.192751	10.074859	135	9.925141	19
42	732587	328	267413	807527	463	192473	074940	135	925060	18
43	732784	328	267216	807805	463	192195	075021	135	924979	17
44	732980	327	267020	808083	463	191917	075103	135	924897	16
45	733177	327	266823	808361	463	191639	075184	135	924816	15
46	733373	327	266627	808638	462	191362	075265	136	924735	14
47	733569	327	266431	808916	462	191084	075346	136	924654	13
48	733765	327	266235	809193	462	190807	075428	136	924572	12
49	733961	326	266039	809471	462	190529	075509	136	924491	11
50	734157	326	265843	809748	462	190252	075591	136	924409	10
51	9.734353	326	10.265647	9.810025	462	10.189975	10.075672	136	9.924328	9
52	734549	326	265451	810302	462	189698	075754	136	924246	8
53	734744	325	265256	810580	462	189420	075836	136	924164	7
54	734939	325	265061	810857	462	189143	075917	136	924083	6
55	735135	325	264865	811134	461	188866	075999	136	924001	5
56	735330	325	264670	811410	461	188590	076081	136	923919	4
57	735525	325	264475	811687	461	188313	076163	136	923837	3
58	735719	324	264281	811964	461	188036	076245	137	923755	2
59	735914	324	264086	812241	461	187759	076327	137	923673	1
60	736109		263891	812517		187483	076409		923591	0
	Cosine.		Secant.	Cotang.		Tang.	Cosec.		Sine.	′

Tangents and Secants. (33°)

/	Sine.	D.	Cosec.	Tang.	D.	Cotang.	Secant.	D.	Cosine.	
0	9.736109	324	10.263891	9.812517	461	10.187483	10.076409	137	9.923591	60
1	736303	324	263697	812794	461	187206	076491	137	923509	59
2	736498	324	263502	813070	461	186930	076573	137	923427	58
3	736692	323	263308	813347	460	186653	076655	137	923345	57
4	736886	323	263114	813623	460	186377	076737	137	923263	56
5	737080	323	262920	813899	460	186101	076819	137	923181	55
6	737274	323	262726	814175	460	185825	076902	137	923098	54
7	737467	323	262533	814452	460	185548	076984	137	923016	53
8	737661	322	262339	814728	460	185272	077067	137	922933	52
9	737855	322	262145	815004	460	184996	077149	137	922851	51
10	738048	322	261952	815279	460	184721	077232	138	922768	50
11	9.738241	322	10.261759	9.815555	459	10.184445	10.077314	138	9.922686	49
12	738434	322	261566	815831	459	184169	077397	138	922603	48
13	738627	321	261373	816107	459	183893	077480	138	922520	47
14	738820	321	261180	816382	459	183618	077562	138	922438	46
15	739013	321	260987	816658	459	183342	077645	138	922355	45
16	739206	321	260794	816933	459	183067	077728	138	922272	44
17	739398	321	260602	817209	459	182791	077811	138	922189	43
18	739590	320	260410	817484	459	182516	077894	138	922106	42
19	739783	320	260217	817759	459	182241	077977	138	922023	41
20	739975	320	260025	818035	458	181965	078060	138	921940	40
21	9.740167	320	10.259833	9.818310	458	10.181690	10.078143	139	9.921857	39
22	740359	320	259641	818585	458	181415	078226	139	921774	38
23	740550	319	259450	818860	458	181140	078309	139	921691	37
24	740742	319	259258	819135	458	180865	078393	139	921607	36
25	740934	319	259066	819410	458	180590	078476	139	921524	35
26	741125	319	258875	819684	458	180316	078559	139	921441	34
27	741316	319	258684	819959	458	180041	078643	139	921357	33
28	741508	318	258492	820234	458	179766	078726	139	921274	32
29	741699	318	258301	820508	457	179492	078810	139	921190	31
30	741889	318	258111	820783	457	179217	078893	139	921107	30
31	9.742080	318	10.257920	9.821057	457	10.178943	10.078977	139	9.921023	29
32	742271	318	257729	821332	457	178668	079061	140	920939	28
33	742462	317	257538	821606	457	178394	079144	140	920856	27
34	742652	317	257348	821880	457	178120	079228	140	920772	26
35	742842	317	257158	822154	457	177846	079312	140	920688	25
36	743033	317	256967	822429	457	177571	079396	140	920604	24
37	743223	317	256777	822703	457	177297	079480	140	920520	23
38	743413	316	256587	822977	456	177023	079564	140	920436	22
39	743602	316	256398	823250	456	176750	079648	140	920352	21
40	743792	316	256208	823524	456	176476	079732	140	920268	20
41	9.743982	316	10.256018	9.823798	456	10.176202	10.079816	140	9.920184	19
42	744171	316	255829	824072	456	175928	079901	140	920099	18
43	744361	315	255639	824345	456	175655	079985	140	920015	17
44	744550	315	255450	824619	456	175381	080069	141	919931	16
45	744739	315	255261	824893	456	175107	080154	141	919846	15
46	744928	315	255072	825166	456	174834	080238	141	919762	14
47	745117	315	254883	825439	455	174561	080323	141	919677	13
48	745306	314	254694	825713	455	174287	080407	141	919593	12
49	745494	314	254506	825986	455	174014	080492	141	919508	11
50	745683	314	254317	826259	455	173741	080576	141	919424	10
51	9.745871	314	10.254129	9.826532	455	10.173468	10.080661	141	9.919339	9
52	746059	314	253941	826805	455	173195	080746	141	919254	8
53	746248	313	253752	827078	455	172922	080831	141	919169	7
54	746436	313	253564	827351	455	172649	080915	141	919085	6
55	746624	313	253376	827624	455	172376	081000	141	919000	5
56	746812	313	253188	827897	454	172103	081085	142	918915	4
57	746999	313	253001	828170	454	171830	081170	142	918830	3
58	747187	312	252813	828442	454	171558	081255	142	918745	2
59	747374	312	252626	828715	454	171285	081341	142	918659	1
60	747562	312	252438	828987	454	171013	081426	142	918574	0
	Cosine.		Secant.	Cotang.		Tang.	Cosec.		Sine.	/

TABLE VI.

(34°) Logarithmic Sines.

′	Sine.	D.	Cosec.	Tang.	D.	Cotang.	Secant.	D.	Cosine.	
0	9.747562	312	10.252438	9.828987	454	10.171013	10.081426	142	9.918574	60
1	747749	312	252251	829260	454	170740	081511	142	918489	59
2	747936	312	252064	829532	454	170468	081596	142	918404	58
3	748123	311	251877	829805	454	170195	081682	142	918318	57
4	748310	311	251690	830077	454	169923	081767	142	918233	56
5	748497	311	251503	830349	453	169651	081853	142	918147	55
6	748683	311	251317	830621	453	169379	081938	142	918062	54
7	748870	311	251130	830893	453	169107	082024	143	917976	53
8	749056	310	250944	831165	453	168835	082109	143	917891	52
9	749243	310	250757	831437	453	168563	082195	143	917805	51
10	749429	310	250571	831709	453	168291	082281	143	917719	50
11	9.749615	310	10.250385	9.831981	453	10.168019	10.082366	143	9.917634	49
12	749801	310	250199	832253	453	167747	082452	143	917548	48
13	749987	309	250013	832525	453	167475	082538	143	917462	47
14	750172	309	249828	832796	453	167204	082624	143	917376	46
15	750358	309	249642	833068	452	166932	082710	143	917290	45
16	750543	309	249457	833339	452	166661	082796	143	917204	44
17	750729	309	249271	833611	452	166389	082882	144	917118	43
18	750914	308	249086	833882	452	166118	082968	144	917032	42
19	751099	308	248901	834154	452	165846	083054	144	916946	41
20	751284	308	248716	834425	452	165575	083141	144	916859	40
21	9.751469	308	10.248531	9.834696	452	10.165304	10.083227	144	9.916773	39
22	751654	308	248346	834967	452	165033	083313	144	916687	38
23	751839	308	248161	835238	452	164762	083400	144	916600	37
24	752023	307	247977	835509	452	164491	083486	144	916514	36
25	752208	307	247792	835780	451	164220	083573	144	916427	35
26	752392	307	247608	836051	451	163949	083659	144	916341	34
27	752576	307	247424	836322	451	163678	083746	144	916254	33
28	752760	307	247240	836593	451	163407	083833	145	916167	32
29	752944	306	247056	836864	451	163136	083919	145	916081	31
30	753128	306	246872	837134	451	162866	084006	145	915994	30
31	9.753312	306	10.246688	9.837405	451	10.162595	10.084093	145	9.915907	29
32	753495	306	246505	837675	451	162325	084180	145	915820	28
33	753679	306	246321	837946	451	162054	084267	145	915733	27
34	753862	305	246138	838216	451	161784	084354	145	915646	26
35	754046	305	245954	838487	450	161513	084441	145	915559	25
36	754229	305	245771	838757	450	161243	084528	145	915472	24
37	754412	305	245588	839027	450	160973	084615	145	915385	23
38	754595	305	245405	839297	450	160703	084703	145	915297	22
39	754778	304	245222	839568	450	160432	084790	145	915210	21
40	754960	304	245040	839838	450	160162	084877	146	915123	20
41	9.755143	304	10.244857	9.840108	450	10.159892	10.084965	146	9.915035	19
42	755326	304	244674	840378	450	159622	085052	146	914948	18
43	755508	304	244492	840647	450	159353	085140	146	914860	17
44	755690	304	244310	840917	449	159083	085227	146	914773	16
45	755872	303	244128	841187	449	158813	085315	146	914685	15
46	756054	303	243946	841457	449	158543	085402	146	914598	14
47	756236	303	243764	841726	449	158274	085490	146	914510	13
48	756418	303	243582	841996	449	158004	085578	146	914422	12
49	756600	303	243400	842266	449	157734	085666	146	914334	11
50	756782	302	243218	842535	449	157465	085754	147	914246	10
51	9.756963	302	10.243037	9.842805	449	10.157195	10.085842	147	9.914158	9
52	757144	302	242856	843074	449	156926	085930	147	914070	8
53	757326	302	242674	843343	449	156657	086018	147	913982	7
54	757507	302	242493	843612	449	156388	086106	147	913894	6
55	757688	301	242312	843882	448	156118	086194	147	913806	5
56	757869	301	242131	844151	448	155849	086282	147	913718	4
57	758050	301	241950	844420	448	155580	086370	147	913630	3
58	758230	301	241770	844689	448	155311	086459	147	913541	2
59	758411	301	241589	844958	448	155042	086547	147	913453	1
60	758591		241409	845227		154773	086635		913365	0
	Cosine.		Secant.	Cotang.		Tang.	Cosec.		Sine.	′

Tangents and Secants. (35°)

/	Sine.	D.	Cosec.	Tang.	D.	Cotang.	Secant.	D.	Cosine.	
0	9.758591	301	10.241409	9.845227	448	10.154773	10.086635	147	9.913365	60
1	758772	300	241228	845496	448	154504	086724	147	913276	59
2	758952	300	241048	845764	448	154236	086813	148	913187	58
3	759132	300	240868	846033	448	153967	086901	148	913099	57
4	759312	300	240688	846302	448	153698	086990	148	913010	56
5	759492	300	240508	846570	447	153430	087078	148	912922	55
6	759672	299	240328	846839	447	153161	087167	148	912833	54
7	759852	299	240148	847107	447	152893	087256	148	912744	53
8	760031	299	239969	847376	447	152624	087345	148	912655	52
9	760211	299	239789	847644	447	152356	087434	148	912566	51
10	760390	299	239610	847913	447	152087	087523	148	912477	50
11	9.760569	298	10.239431	9.848181	447	10.151819	10.087612	148	9.912388	49
12	760748	298	239252	848449	447	151551	087701	149	912299	48
13	760927	298	239073	848717	447	151283	087790	149	912210	47
14	761106	298	238894	848986	447	151014	087879	149	912121	46
15	761285	298	238715	849254	447	150746	087969	149	912031	45
16	761464	298	238536	849522	447	150478	088058	149	911942	44
17	761642	297	238358	849790	446	150210	088147	149	911853	43
18	761821	297	238179	850058	446	149942	088237	149	911763	42
19	761999	297	238001	850325	446	149675	088326	149	911674	41
20	762177	297	237823	850593	446	149407	088416	149	911584	40
21	9.762356	297	10.237644	9.850861	446	10.149139	10.088505	149	9.911495	39
22	762534	296	237466	851129	446	148871	088595	149	911405	38
23	762712	296	237288	851396	446	148604	088685	150	911315	37
24	762889	296	237111	851664	446	148336	088774	150	911226	36
25	763067	296	236933	851931	446	148069	088864	150	911136	35
26	763245	296	236755	852199	446	147801	088954	150	911046	34
27	763422	296	236578	852466	446	147534	089044	150	910956	33
28	763600	296	236400	852733	446	147267	089134	150	910866	32
29	763777	295	236223	853001	445	146999	089224	150	910776	31
30	763954	295	236046	853268	445	146732	089314	150	910686	30
31	9.764131	295	10.235869	9.853535	445	10.146465	10.089404	150	9.910596	29
32	764308	295	235692	853802	445	146198	089494	150	910506	28
33	764485	294	235515	854069	445	145931	089585	150	910415	27
34	764662	294	235338	854336	445	145664	089675	151	910325	26
35	764838	294	235162	854603	445	145397	089765	151	910235	25
36	765015	294	234985	854870	445	145130	089856	151	910144	24
37	765191	294	234809	855137	445	144863	089946	151	910054	23
38	765367	294	234633	855404	445	144596	090037	151	909963	22
39	765544	293	234456	855671	444	144329	090127	151	909873	21
40	765720	293	234280	855938	444	144062	090218	151	909782	20
41	9.765896	293	10.234104	9.856204	444	10.143796	10.090309	151	9.909691	19
42	766072	293	233928	856471	444	143529	090399	151	909601	18
43	766247	293	233753	856737	444	143263	090490	151	909510	17
44	766423	293	233577	857004	444	142996	090581	151	909419	16
45	766598	292	233402	857270	444	142730	090672	152	909328	15
46	766774	292	233226	857537	444	142463	090763	152	909237	14
47	766949	292	233051	857803	444	142197	090854	152	909146	13
48	767124	292	232876	858069	444	141931	090945	152	909055	12
49	767300	292	232700	858336	444	141664	091036	152	908964	11
50	767475	291	232525	858602	443	141398	091127	152	908873	10
51	9.767649	291	10.232351	9.858868	443	10.141132	10.091219	152	9.908781	9
52	767824	291	232176	859134	443	140866	091310	152	908690	8
53	767999	291	232001	859400	443	140600	091401	152	908599	7
54	768173	291	231827	859666	443	140334	091493	152	908507	6
55	768348	290	231652	859932	443	140068	091584	153	908416	5
56	768522	290	231478	860198	443	139802	091676	153	908324	4
57	768697	290	231303	860464	443	139536	091767	153	908233	3
58	768871	290	231129	860730	443	139270	091859	153	908141	2
59	769045	290	230955	860995	443	139005	091951	153	908049	1
60	769219	290	230781	861261	443	138739	092042	153	907958	0
	Cosine.		Secant.	Cotang.		Tang.	Cosec.		Sine.	/

(36°) Logarithmic Sines.

/	Sine.	D.	Cosec.	Tang.	D.	Cotang.	Secant.	D.	Cosine.	
0	9.769219	290	10.230781	9.861261	443	10.138739	10.092042	153	9.907958	60
1	769393	289	230607	861527	443	138473	092134	153	907866	59
2	769566	289	230434	861792	442	138208	092226	153	907774	58
3	769740	289	230260	862058	442	137942	092318	153	907682	57
4	769913	289	230087	862323	442	137677	092410	153	907590	56
5	770087	289	229913	862589	442	137411	092502	153	907498	55
6	770260	288	229740	862854	442	137146	092594	153	907406	54
7	770433	288	229567	863119	442	136881	092686	154	907314	53
8	770606	288	229394	863385	442	136615	092778	154	907222	52
9	770779	288	229221	863650	442	136350	092871	154	907129	51
10	770952	288	229048	863915	442	136085	092963	154	907037	50
11	9.771125	288	10.228875	9.864180	442	10.135820	10.093055	154	9.906945	49
12	771298	287	228702	864445	442	135555	093148	154	906852	48
13	771470	287	228530	864710	442	135290	093240	154	906760	47
14	771643	287	228357	864975	441	135025	093333	154	906667	46
15	771815	287	228185	865240	441	134760	093425	154	906575	45
16	771987	287	228013	865505	441	134495	093518	154	906482	44
17	772159	287	227841	865770	441	134230	093611	155	906389	43
18	772331	286	227669	866035	441	133965	093704	155	906296	42
19	772503	286	227497	866300	441	133700	093796	155	906204	41
20	772675	286	227325	866564	441	133436	093889	155	906111	40
21	9.772847	286	10.227153	9.866829	441	10.133171	10.093982	155	9.906018	39
22	773018	286	226982	867094	441	132906	094075	155	905925	38
23	773190	286	226810	867358	441	132642	094168	155	905832	37
24	773361	285	226639	867623	441	132377	094261	155	905739	36
25	773533	285	226467	867887	441	132113	094355	155	905645	35
26	773704	285	226296	868152	440	131848	094448	155	905552	34
27	773875	285	226125	868416	440	131584	094541	155	905459	33
28	774046	285	225954	868680	440	131320	094634	156	905366	32
29	774217	285	225783	868945	440	131055	094728	156	905272	31
30	774388	284	225612	869209	440	130791	094821	156	905179	30
31	9.774558	284	10.225442	9.869473	440	10.130527	10.094915	156	9.905085	29
32	774729	284	225271	869737	440	130263	095008	156	904992	28
33	774899	284	225101	870001	440	129999	095102	156	904898	27
34	775070	284	224930	870265	440	129735	095196	156	904804	26
35	775240	284	224760	870529	440	129471	095289	156	904711	25
36	775410	283	224590	870793	440	129207	095383	156	904617	24
37	775580	283	224420	871057	440	128943	095477	156	904523	23
38	775750	283	224250	871321	440	128679	095571	157	904429	22
39	775920	283	224080	871585	440	128415	095665	157	904335	21
40	776090	283	223910	871849	439	128151	095759	157	904241	20
41	9.776259	283	10.223741	9.872112	439	10.127888	10.095853	157	9.904147	19
42	776429	282	223571	872376	439	127624	095947	157	904053	18
43	776598	282	223402	872640	439	127360	096041	157	903959	17
44	776768	282	223232	872903	439	127097	096136	157	903864	16
45	776937	282	223063	873167	439	126833	096230	157	903770	15
46	777106	282	222894	873430	439	126570	096324	157	903676	14
47	777275	281	222725	873694	439	126306	096419	157	903581	13
48	777444	281	222556	873957	439	126043	096513	157	903487	12
49	777613	281	222387	874220	439	125780	096608	158	903392	11
50	777781	281	222219	874484	439	125516	096702	158	903298	10
51	9.777950	281	10.222050	9.874747	439	10.125253	10.096797	158	9.903203	9
52	778119	281	221881	875010	439	124990	096892	158	903108	8
53	778287	280	221713	875273	438	124727	096986	158	903014	7
54	778455	280	221545	875536	438	124464	097081	158	902919	6
55	778624	280	221376	875800	438	124200	097176	158	902824	5
56	778792	280	221208	876063	438	123937	097271	158	902729	4
57	778960	280	221040	876326	438	123674	097366	158	902634	3
58	779128	280	220872	876589	438	123411	097461	159	902539	2
59	779295	279	220705	876851	438	123149	097556	159	902444	1
60	779463		220537	877114	438	122886	097651		902349	0
	Cosine.		Secant.	Cotang.		Tang.	Cosec.		Sine.	/

Tangents and Secants. (37°)

′	Sine.	D.	Cosec.	Tang.	D.	Cotang.	Secant.	D.	Cosine.	
0	9.779463	279	10.220537	9.877114	438	10.122886	10.097651	159	9.902349	60
1	779631	279	220369	877377	438	122623	097747	159	902253	59
2	779798	279	220202	877640	438	122360	097842	159	902158	58
3	779966	279	220034	877903	438	122097	097937	159	902063	57
4	780133	279	219867	878165	438	121835	098033	159	901967	56
5	780300	278	219700	878428	438	121572	098128	159	901872	55
6	780467	278	219533	878691	438	121309	098224	159	901776	54
7	780634	278	219366	878953	438	121047	098319	159	901681	53
8	780801	278	219199	879216	437	120784	098415	159	901585	52
9	780968	278	219032	879478	437	120522	098510	159	901490	51
10	781134	278	218866	879741	437	120259	098606	160	901394	50
11	9.781301	277	10.218699	9.880003	437	10.119997	10.098702	160	9.901298	49
12	781468	277	218532	880265	437	119735	098798	160	901202	48
13	781634	277	218366	880528	437	119472	098894	160	901106	47
14	781800	277	218200	880790	437	119210	098990	160	901010	46
15	781966	277	218034	881052	437	118948	099086	160	900914	45
16	782132	277	217868	881314	437	118686	099182	160	900818	44
17	782298	276	217702	881576	437	118424	099278	160	900722	43
18	782464	276	217536	881839	437	118161	099374	160	900626	42
19	782630	276	217370	882101	437	117899	099471	160	900529	41
20	782796	276	217204	882363	436	117637	099567	161	900433	40
21	9.782961	276	10.217039	9.882625	436	10.117375	10.099663	161	9.900337	39
22	783127	276	216873	882887	436	117113	099760	161	900240	38
23	783292	275	216708	883148	436	116852	099856	161	900144	37
24	783458	275	216542	883410	436	116590	099953	161	900047	36
25	783623	275	216377	883672	436	116328	100049	161	899951	35
26	783788	275	216212	883934	436	116066	100146	161	899854	34
27	783953	275	216047	884196	436	115804	100243	161	899757	33
28	784118	275	215882	884457	436	115543	100340	161	899660	32
29	784282	274	215718	884719	436	115281	100436	161	899564	31
30	784447	274	215553	884980	436	115020	100533	162	899467	30
31	9.784612	274	10.215388	9.885242	436	10.114758	10.100630	162	9.899370	29
32	784776	274	215224	885503	436	114497	100727	162	899273	28
33	784941	274	215059	885765	436	114235	100824	162	899176	27
34	785105	274	214895	886026	436	113974	100922	162	899078	26
35	785269	273	214731	886288	436	113712	101019	162	898981	25
36	785433	273	214567	886549	436	113451	101116	162	898884	24
37	785597	273	214403	886810	435	113190	101213	162	898787	23
38	785761	273	214239	887072	435	112928	101311	162	898689	22
39	785925	273	214075	887333	435	112667	101408	162	898592	21
40	786089	273	213911	887594	435	112406	101506	163	898494	20
41	9.786252	272	10.213748	9.887855	435	10.112145	10.101603	163	9.898397	19
42	786416	272	213584	888116	435	111884	101701	163	898299	18
43	786579	272	213421	888377	435	111623	101798	163	898202	17
44	786742	272	213258	888639	435	111361	101896	163	898104	16
45	786906	272	213094	888900	435	111100	101994	163	898006	15
46	787069	272	212931	889160	435	110840	102092	163	897908	14
47	787232	271	212768	889421	435	110579	102190	163	897810	13
48	787395	271	212605	889682	435	110318	102288	163	897712	12
49	787557	271	212443	889943	435	110057	102386	163	897614	11
50	787720	271	212280	890204	434	109796	102484	163	897516	10
51	9.787883	271	10.212117	9.890465	434	10.109535	10.102582	164	9.897418	9
52	788045	271	211955	890725	434	109275	102680	164	897320	8
53	788208	271	211792	890986	434	109014	102778	164	897222	7
54	788370	270	211630	891247	434	108753	102877	164	897123	6
55	788532	270	211468	891507	434	108493	102975	164	897025	5
56	788694	270	211306	891768	434	108232	103074	164	896926	4
57	788856	270	211144	892028	434	107972	103172	164	896828	3
58	789018	270	210982	892289	434	107711	103271	164	896729	2
59	789180	270	210820	892549	434	107451	103369	164	896631	1
60	789342	270	210658	892810	434	107190	103468	164	896532	0
	Cosine.		Secant.	Cotang.		Tang.	Cosec.		Sine.	′

TABLE VI.

(38°) Logarithmic Sines.

′	Sine.	D.	Cosec.	Tang.	D.	Cotang.	Secant.	D.	Cosine.	
0	9.789342	269	10.210658	9.892810	434	10.107190	10.103468	164	9.896532	60
1	789504	269	210496	893070	434	106930	103567	165	896433	59
2	789665	269	210335	893331	434	106669	103665	165	896335	58
3	789827	269	210173	893591	434	106409	103764	165	896236	57
4	789988	269	210012	893851	434	106149	103863	165	896137	56
5	790149	269	209851	894111	434	105889	103962	165	896038	55
6	790310	269	209690	894371	434	105629	104061	165	895939	54
7	790471	268	209529	894632	433	105368	104160	165	895840	53
8	790632	268	209368	894892	433	105108	104259	165	895741	52
9	790793	268	209207	895152	433	104848	104359	165	895641	51
10	790954	268	209046	895412	433	104588	104458	165	895542	50
11	9.791115	268	10.208885	9.895672	433	10.104328	10.104557	166	9.895443	49
12	791275	267	208725	895932	433	104068	104657	166	895343	48
13	791436	267	208564	896192	433	103808	104756	166	895244	47
14	791596	267	208404	896452	433	103548	104855	166	895145	46
15	791757	267	208243	896712	433	103288	104955	166	895045	45
16	791917	267	208083	896971	433	103029	105055	166	894945	44
17	792077	267	207923	897231	433	102769	105154	166	894846	43
18	792237	266	207763	897491	433	102509	105254	166	894746	42
19	792397	266	207603	897751	433	102249	105354	166	894646	41
20	792557	266	207443	898010	433	101990	105454	166	894546	40
21	9.792716	266	10.207284	9.898270	433	10.101730	10.105554	167	9.894446	39
22	792876	266	207124	898530	433	101470	105654	167	894346	38
23	793035	266	206965	898789	433	101211	105754	167	894246	37
24	793195	265	206805	899049	432	100951	105854	167	894146	36
25	793354	265	206646	899308	432	100692	105954	167	894046	35
26	793514	265	206486	899568	432	100432	106054	167	893946	34
27	793673	265	206327	899827	432	100173	106154	167	893846	33
28	793832	265	206168	900086	432	099914	106255	167	893745	32
29	793991	265	206009	900346	432	099654	106355	167	893645	31
30	794150	264	205850	900605	432	099395	106456	167	893544	30
31	9.794308	264	10.205692	9.900864	432	10.099136	10.106556	168	9.893444	29
32	794467	264	205533	901124	432	098876	106657	168	893343	28
33	794626	264	205374	901383	432	098617	106757	168	893243	27
34	794784	264	205216	901642	432	098358	106858	168	893142	26
35	794942	264	205058	901901	432	098099	106959	168	893041	25
36	795101	264	204899	902160	432	097840	107060	168	892940	24
37	795259	263	204741	902419	432	097581	107161	168	892839	23
38	795417	263	204583	902679	432	097321	107261	168	892739	22
39	795575	263	204425	902938	432	097062	107362	168	892638	21
40	795733	263	204267	903197	431	096803	107464	168	892536	20
41	9.795891	263	10.204109	9.903455	431	10.096545	10.107565	169	9.892435	19
42	796049	263	203951	903714	431	096286	107666	169	892334	18
43	796206	263	203794	903973	431	096027	107767	169	892233	17
44	796364	262	203636	904232	431	095768	107868	169	892132	16
45	796521	262	203479	904491	431	095509	107970	169	892030	15
46	796679	262	203321	904750	431	095250	108071	169	891929	14
47	796836	262	203164	905008	431	094992	108173	169	891827	13
48	796993	262	203007	905267	431	094733	108274	169	891726	12
49	797150	262	202850	905526	431	094474	108376	169	891624	11
50	797307	261	202693	905784	431	094216	108477	170	891523	10
51	9.797464	261	10.202536	9.906043	431	10.093957	10.108579	170	9.891421	9
52	797621	261	202379	906302	431	093698	108681	170	891319	8
53	797777	261	202223	906560	431	093440	108783	170	891217	7
54	797934	261	202066	906819	431	093181	108885	170	891115	6
55	798091	261	201909	907077	431	092923	108987	170	891013	5
56	798247	261	201753	907336	431	092664	109089	170	890911	4
57	798403	260	201597	907594	431	092406	109191	170	890809	3
58	798560	260	201440	907852	431	092148	109293	170	890707	2
59	798716	260	201284	908111	430	091889	109395	170	890605	1
60	798872		201128	908369		091631	109497		890503	0
	Cosine.		Secant.	Cotang.		Tang.	Cosec.		Sine.	′

Tangents and Secants. (39°)

′	Sine.	D.	Cosec.	Tang.	D.	Cotang.	Secant.	D.	Cosine.	
0	9.798872	260	10.201128	9.908369	430	10.091631	10.109497	170	9.890503	60
1	799028	260	200972	908628	430	091372	109600	171	890400	59
2	799184	260	200816	908886	430	091114	109702	171	890298	58
3	799339	259	200661	909144	430	090856	109805	171	890195	57
4	799495	259	200505	909402	430	090598	109907	171	890093	56
5	799651	259	200349	909660	430	090340	110010	171	889990	55
6	799806	259	200194	909918	430	090082	110112	171	889888	54
7	799962	259	200038	910177	430	089823	110215	171	889785	53
8	800117	259	199883	910435	430	089565	110318	171	889682	52
9	800272	258	199728	910693	430	089307	110421	171	889579	51
10	800427	258	199573	910951	430	089049	110523	171	889477	50
11	9.800582	258	10.199418	9.911209	430	10.088791	10.110626	172	9.889374	49
12	800737	258	199263	911467	430	088533	110729	172	889271	48
13	800892	258	199108	911724	430	088276	110832	172	889168	47
14	801047	258	198953	911982	430	088018	110936	172	889064	46
15	801201	258	198799	912240	430	087760	111039	172	888961	45
16	801356	257	198644	912498	430	087502	111142	172	888858	44
17	801511	257	198489	912756	430	087244	111245	172	888755	43
18	801665	257	198335	913014	429	086986	111349	172	888651	42
19	801819	257	198181	913271	429	086729	111452	172	888548	41
20	801973	257	198027	913529	429	086471	111556	173	888444	40
21	9.802128	257	10.197872	9.913787	429	10.086213	10.111659	173	9.888341	39
22	802282	256	197718	914044	429	085956	111763	173	888237	38
23	802436	256	197564	914302	429	085698	111866	173	888134	37
24	802589	256	197411	914560	429	085440	111970	173	888030	36
25	802743	256	197257	914817	429	085183	112074	173	887926	35
26	802897	256	197103	915075	429	084925	112178	173	887822	34
27	803050	256	196950	915332	429	084668	112282	173	887718	33
28	803204	256	196796	915590	429	084410	112386	173	887614	32
29	803357	256	196643	915847	429	084153	112490	173	887510	31
30	803511	255	196489	916104	429	083896	112594	174	887406	30
31	9.803664	255	10.196336	9.916362	429	10.083638	10.112698	174	9.887302	29
32	803817	255	196183	916619	429	083381	112802	174	887198	28
33	803970	255	196030	916877	429	083123	112907	174	887093	27
34	804123	255	195877	917134	429	082866	113011	174	886989	26
35	804276	254	195724	917391	429	082609	113115	174	886885	25
36	804428	254	195572	917648	429	082352	113220	174	886780	24
37	804581	254	195419	917905	429	082095	113324	174	886676	23
38	804734	254	195266	918163	428	081837	113429	174	886571	22
39	804886	254	195114	918420	428	081580	113534	174	886466	21
40	805039	254	194961	918677	428	081323	113638	175	886362	20
41	9.805191	254	10.194809	9.918934	428	10.081066	10.113743	175	9.886257	19
42	805343	253	194657	919191	428	080809	113848	175	886152	18
43	805495	253	194505	919448	428	080552	113953	175	886047	17
44	805647	253	194353	919705	428	080295	114058	175	885942	16
45	805799	253	194201	919962	428	080038	114163	175	885837	15
46	805951	253	194049	920219	428	079781	114268	175	885732	14
47	806103	253	193897	920476	428	079524	114373	175	885627	13
48	806254	253	193746	920733	428	079267	114478	175	885522	12
49	806406	252	193594	920990	428	079010	114584	175	885416	11
50	806557	252	193443	921247	428	078753	114689	176	885311	10
51	9.806709	252	10.193291	9.921503	428	10.078497	10.114795	176	9.885205	9
52	806860	252	193140	921760	428	078240	114900	176	885100	8
53	807011	252	192989	922017	428	077983	115006	176	884994	7
54	807163	252	192837	922274	428	077726	115111	176	884889	6
55	807314	252	192686	922530	428	077470	115217	176	884783	5
56	807465	251	192535	922787	428	077213	115323	176	884677	4
57	807615	251	192385	923044	428	076956	115428	176	884572	3
58	807766	251	192234	923300	428	076700	115534	176	884466	2
59	807917	251	192083	923557	427	076443	115640	176	884360	1
60	808067		191933	923813		076187	115746		884254	0
	Cosine.		Secant.	Cotang.		Tang.	Cosec.		Sine.	′

(40°) Logarithmic Sines.

′	Sine.	D.	Cosec.	Tang.	D.	Cotang.	Secant.	D.	Cosine.	
0	9.808067	251	10.191933	9.923813	427	10.076187	10.115746	177	9.884254	60
1	808218	251	191782	924070	427	075930	115852	177	884148	59
2	808368	251	191632	924327	427	075673	115958	177	884042	58
3	808519	250	191481	924583	427	075417	116064	177	883936	57
4	808669	250	191331	924840	427	075160	116171	177	883829	56
5	808819	250	191181	925096	427	074904	116277	177	883723	55
6	808969	250	191031	925352	427	074648	116383	177	883617	54
7	809119	250	190881	925609	427	074391	116490	177	883510	53
8	809269	250	190731	925865	427	074135	116596	177	883404	52
9	809419	249	190581	926122	427	073878	116703	178	883297	51
10	809569	249	190431	926378	427	073622	116809	178	883191	50
11	9.809718	249	10.190282	9.926634	427	10.073366	10.116916	178	9.883084	49
12	809868	249	190132	926890	427	073110	117023	178	882977	48
13	810017	249	189983	927147	427	072853	117129	178	882871	47
14	810167	249	189833	927403	427	072597	117236	178	882764	46
15	810316	248	189684	927659	427	072341	117343	178	882657	45
16	810465	248	189535	927915	427	072085	117450	178	882550	44
17	810614	248	189386	928171	427	071829	117557	178	882443	43
18	810763	248	189237	928427	427	071573	117664	179	882336	42
19	810912	248	189088	928683	427	071317	117771	179	882229	41
20	811061	248	188939	928940	427	071060	117879	179	882121	40
21	9.811210	248	10.188790	9.929196	427	10.070804	10.117986	179	9.882014	39
22	811358	247	188642	929452	427	070548	118093	179	881907	38
23	811507	247	188493	929708	427	070292	118201	179	881799	37
24	811655	247	188345	929964	426	070036	118308	179	881692	36
25	811804	247	188196	930220	426	069780	118416	179	881584	35
26	811952	247	188048	930475	426	069525	118523	179	881477	34
27	812100	247	187900	930731	426	069269	118631	179	881369	33
28	812248	247	187752	930987	426	069013	118739	180	881261	32
29	812396	246	187604	931243	426	068757	118847	180	881153	31
30	812544	246	187456	931499	426	068501	118954	180	881046	30
31	9.812692	246	10.187308	9.931755	426	10.068245	10.119062	180	9.880938	29
32	812840	246	187160	932010	426	067990	119170	180	880830	28
33	812988	246	187012	932266	426	067734	119278	180	880722	27
34	813135	246	186865	932522	426	067478	119387	180	880613	26
35	813283	246	186717	932778	426	067222	119495	180	880505	25
36	813430	245	186570	933033	426	066967	119603	180	880397	24
37	813578	245	186422	933289	426	066711	119711	181	880289	23
38	813725	245	186275	933545	426	066455	119820	181	880180	22
39	813872	245	186128	933800	426	066200	119928	181	880072	21
40	814019	245	185981	934056	426	065944	120037	181	879963	20
41	9.814166	245	10.185834	9.934311	426	10.065689	10.120145	181	9.879855	19
42	814313	245	185687	934567	426	065433	120254	181	879746	18
43	814460	244	185540	934823	426	065177	120363	181	879637	17
44	814607	244	185393	935078	426	064922	120471	181	879529	16
45	814753	244	185247	935333	426	064667	120580	181	879420	15
46	814900	244	185100	935589	426	064411	120689	181	879311	14
47	815046	244	184954	935844	426	064156	120798	182	879202	13
48	815193	244	184807	936100	426	063900	120907	182	879093	12
49	815339	244	184661	936355	426	063645	121016	182	878984	11
50	815485	243	184515	936610	426	063390	121125	182	878875	10
51	9.815632	243	10.184368	9.936866	425	10.063134	10.121234	182	9.878766	9
52	815778	243	184222	937121	425	062879	121344	182	878656	8
53	815924	243	184076	937376	425	062624	121453	182	878547	7
54	816069	243	183931	937632	425	062368	121562	182	878438	6
55	816215	243	183785	937887	425	062113	121672	182	878328	5
56	816361	243	183639	938142	425	061858	121781	183	878219	4
57	816507	242	183493	938398	425	061602	121891	183	878109	3
58	816652	242	183348	938653	425	061347	122001	183	877999	2
59	816798	242	183202	938908	425	061092	122110	183	877890	1
60	816943	242	183057	939163	425	060837	122220	183	877780	0
	Cosine.		Secant.	Cotang.		Tang.	Cosec.		Sine	′

TABLE VI.

Tangents and Secants. (41°)

′	Sine.	D.	Cosec.	Tang.	D.	Cotang.	Secant.	D.	Cosine.	
0	9.816943	242	10.183057	9.939163	425	10.060837	10.122220	183	9.877780	60
1	817088	242	182912	939418	425	060582	122330	183	877670	59
2	817233	242	182767	939673	425	060327	122440	183	877560	58
3	817379	242	182621	939928	425	060072	122550	183	877450	57
4	817524	241	182476	940183	425	059817	122660	183	877340	56
5	817668	241	182332	940438	425	059562	122770	184	877230	55
6	817813	241	182187	940694	425	059306	122880	184	877120	54
7	817958	241	182042	940949	425	059051	122990	184	877010	53
8	818103	241	181897	941204	425	058796	123101	184	876899	52
9	818247	241	181753	941458	425	058542	123211	184	876789	51
10	818392	241	181608	941714	425	058286	123322	184	876678	50
11	9.818536	240	10.181464	9.941968	425	10.058032	10.123432	184	9.876568	49
12	818681	240	181319	942223	425	057777	123543	184	876457	48
13	818825	240	181175	942478	425	057522	123653	184	876347	47
14	818969	240	181031	942733	425	057267	123764	185	876236	46
15	819113	240	180887	942988	425	057012	123875	185	876125	45
16	819257	240	180743	943243	425	056757	123986	185	876014	44
17	819401	240	180599	943498	425	056502	124096	185	875904	43
18	819545	239	180455	943752	425	056248	124207	185	875793	42
19	819689	239	180311	944007	425	055993	124318	185	875682	41
20	819832	239	180168	944262	425	055738	124429	185	875571	40
21	9.819976	239	10.180024	9.944517	425	10.055483	10.124541	185	9.875459	39
22	820120	239	179880	944771	424	055229	124652	185	875348	38
23	820263	239	179737	945026	424	054974	124763	185	875237	37
24	820406	239	179594	945281	424	054719	124874	186	875126	36
25	820550	238	179450	945535	424	054465	124986	186	875014	35
26	820693	238	179307	945790	424	054210	125097	186	874903	34
27	820836	238	179164	946045	424	053955	125209	186	874791	33
28	820979	238	179021	946299	424	053701	125320	186	874680	32
29	821122	238	178878	946554	424	053446	125432	186	874568	31
30	821265	238	178735	946808	424	053192	125544	186	874456	30
31	9.821407	238	10.178593	9.947063	424	10.052937	10.125656	186	9.874344	29
32	821550	238	178450	947318	424	052682	125768	187	874232	28
33	821693	237	178307	947572	424	052428	125879	187	874121	27
34	821835	237	178165	947826	424	052174	125991	187	874009	26
35	821977	237	178023	948081	424	051919	126104	187	873896	25
36	822120	237	177880	948336	424	051664	126216	187	873784	24
37	822262	237	177738	948590	424	051410	126328	187	873672	23
38	822404	237	177596	948844	424	051156	126440	187	873560	22
39	822546	237	177454	949099	424	050901	126552	187	873448	21
40	822688	236	177312	949353	424	050647	126665	187	873335	20
41	9.822830	236	10.177170	9.949607	424	10.050393	10.126777	187	9.873223	19
42	822972	236	177028	949862	424	050138	126890	188	873110	18
43	823114	236	176886	950116	424	049884	127002	188	872998	17
44	823255	236	176745	950370	424	049630	127115	188	872885	16
45	823397	236	176603	950625	424	049375	127228	188	872772	15
46	823539	236	176461	950879	424	049121	127341	188	872659	14
47	823680	235	176320	951133	424	048867	127453	188	872547	13
48	823821	235	176179	951388	424	048612	127566	188	872434	12
49	823963	235	176037	951642	424	048358	127679	188	872321	11
50	824104	235	175896	951896	424	048104	127792	188	872208	10
51	9.824245	235	10.175755	9.952150	424	10.047850	10.127905	189	9.872095	9
52	824386	235	175614	952405	424	047595	128019	189	871981	8
53	824527	235	175473	952659	424	047341	128132	189	871868	7
54	824668	234	175332	952913	424	047087	128245	189	871755	6
55	824808	234	175192	953167	423	046833	128359	189	871641	5
56	824949	234	175051	953421	423	046579	128472	189	871528	4
57	825090	234	174910	953675	423	046325	128586	189	871414	3
58	825230	234	174770	953929	423	046071	128699	189	871301	2
59	825371	234	174629	954183	423	045817	128813	189	871187	1
60	825511		174489	954437		045563	128927		871073	0
	Cosine.		Secant	Cotang.		Tang.	Cosec.		Sine.	′

TABLE VI.

(42°) Logarithmic Sines.

′	Sine.	D.	Cosec.	Tang.	D.	Cotang.	Secant.	D.	Cosine.	
0	9.825511	234	10.174489	9.954437	423	10.045563	10.128927	190	9.871073	60
1	825651	233	174349	954691	423	045309	129040	190	870960	59
2	825791	233	174209	954945	423	045055	129154	190	870846	58
3	825931	233	174069	955200	423	044800	129268	190	870732	57
4	826071	233	173929	955454	423	044546	129382	190	870618	56
5	826211	233	173789	955707	423	044293	129496	190	870504	55
6	826351	233	173649	955961	423	044039	129610	190	870390	54
7	826491	233	173509	956215	423	043785	129724	190	870276	53
8	826631	233	173369	956469	423	043531	129839	190	870161	52
9	826770	232	173230	956723	423	043277	129953	191	870047	51
10	826910	232	173090	956977	423	043023	130067	191	869933	50
11	9.827049	232	10.172951	9.957231	423	10.042769	10.130182	191	9.869818	49
12	827189	232	172811	957485	423	042515	130296	191	869704	48
13	827328	232	172672	957739	423	042261	130411	191	869589	47
14	827467	232	172533	957993	423	042007	130526	191	869474	46
15	827606	232	172394	958246	423	041754	130640	191	869360	45
16	827745	232	172255	958500	423	041500	130755	191	869245	44
17	827884	231	172116	958754	423	041246	130870	191	869130	43
18	828023	231	171977	959008	423	040992	130985	192	869015	42
19	828162	231	171838	959262	423	040738	131100	192	868900	41
20	828301	231	171699	959516	423	040484	131215	192	868785	40
21	9.828439	231	10.171561	9.959769	423	10.040231	10.131330	192	9.868670	39
22	828578	231	171422	960023	423	039977	131445	192	868555	38
23	828716	231	171284	960277	423	039723	131560	192	868440	37
24	828855	230	171145	960531	423	039469	131676	192	868324	36
25	828993	230	171007	960784	423	039216	131791	192	868209	35
26	829131	230	170869	961038	423	038962	131907	192	868093	34
27	829269	230	170731	961291	423	038709	132022	193	867978	33
28	829407	230	170593	961545	423	038455	132138	193	867862	32
29	829545	230	170455	961799	423	038201	132253	193	867747	31
30	829683	230	170317	962052	423	037948	132369	193	867631	30
31	9.829821	229	10.170179	9.962306	423	10.037694	10.132485	193	9.867515	29
32	829959	229	170041	962560	423	037440	132601	193	867399	28
33	830097	229	169903	962813	423	037187	132717	193	867283	27
34	830234	229	169766	963067	423	036933	132833	193	867167	26
35	830372	229	169628	963320	423	036680	132949	193	867051	25
36	830509	229	169491	963574	423	036426	133065	194	866935	24
37	830646	229	169354	963827	423	036173	133181	194	866819	23
38	830784	229	169216	964081	423	035919	133297	194	866703	22
39	830921	228	169079	964335	423	035665	133414	194	866586	21
40	831058	228	168942	964588	422	035412	133530	194	866470	20
41	9.831195	228	10.168805	9.964842	422	10.035158	10.133647	194	9.866353	19
42	831332	228	168668	965095	422	034905	133763	194	866237	18
43	831469	228	168531	965349	422	034651	133880	194	866120	17
44	831606	228	168394	965602	422	034398	133996	195	866004	16
45	831742	228	168258	965855	422	034145	134113	195	865887	15
46	831879	228	168121	966109	422	033891	134230	195	865770	14
47	832015	227	167985	966362	422	033638	134347	195	865653	13
48	832152	227	167848	966616	422	033384	134464	195	865536	12
49	832288	227	167712	966869	422	033131	134581	195	865419	11
50	832425	227	167575	967123	422	032877	134698	195	865302	10
51	9.832561	227	10.167439	9.967376	422	10.032624	10.134815	195	9.865185	9
52	832697	227	167303	967629	422	032371	134932	195	865068	8
53	832833	227	167167	967883	422	032117	135050	195	864950	7
54	832969	226	167031	968136	422	031864	135167	196	864833	6
55	833105	226	166895	968389	422	031611	135284	196	864716	5
56	833241	226	166759	968643	422	031357	135402	196	864598	4
57	833377	226	166623	968896	422	031104	135519	196	864481	3
58	833512	226	166488	969149	422	030851	135637	196	864363	2
59	833648	226	166352	969403	422	030597	135755	196	864245	1
60	833783		166217	969656		030344	135873		864127	0
	Cosine.		Secant.	Cotang.		Tang.	Cosec.		Sine.	′

Tangents and Secants. (43°)

′	Sine.	D.	Cosec.	Tang.	D.	Cotang.	Secant.	D.	Cosine.	
0	9.833783	226	10.166217	9.969656	422	10.030344	10.135873	196	9.864127	60
1	833919	225	166081	969909	422	030091	135990	196	864010	59
2	834054	225	165946	970162	422	029838	136108	197	863892	58
3	834189	225	165811	970416	422	029584	136226	197	863774	57
4	834325	225	165675	970669	422	029331	136344	197	863656	56
5	834460	225	165540	970922	422	029078	136462	197	863538	55
6	834595	225	165405	971175	422	028825	136581	197	863419	54
7	834730	225	165270	971429	422	028571	136699	197	863301	53
8	834865	225	165135	971682	422	028318	136817	197	863183	52
9	834999	224	165001	971935	422	028065	136936	197	863064	51
10	835134	224	164866	972188	422	027812	137054	198	862946	50
11	9.835269	224	10.164731	9.972441	422	10.027559	10.137173	198	9.862827	49
12	835403	224	164597	972694	422	027306	137291	198	862709	48
13	835538	224	164462	972948	422	027052	137410	198	862590	47
14	835672	224	164328	973201	422	026799	137529	198	862471	46
15	835807	224	164193	973454	422	026546	137647	198	862353	45
16	835941	224	164059	973707	422	026293	137766	198	862234	44
17	836075	223	163925	973960	422	026040	137885	198	862115	43
18	836209	223	163791	974213	422	025787	138004	198	861996	42
19	836343	223	163657	974466	422	025534	138123	198	861877	41
20	836477	223	163523	974719	422	025281	138242	199	861758	40
21	9.836611	223	10.163389	9.974973	422	10.025027	10.138362	199	9.861638	39
22	836745	223	163255	975226	422	024774	138481	199	861519	38
23	836878	223	163122	975479	422	024521	138600	199	861400	37
24	837012	222	162988	975732	422	024268	138720	199	861280	36
25	837146	222	162854	975985	422	024015	138839	199	861161	35
26	837279	222	162721	976238	422	023762	138959	199	861041	34
27	837412	222	162588	976491	422	023509	139078	199	860922	33
28	837546	222	162454	976744	422	023256	139198	199	860802	32
29	837679	222	162321	976997	422	023003	139318	199	860682	31
30	837812	222	162188	977250	422	022750	139438	200	860562	30
31	9.837945	222	10.162055	9.977503	422	10.022497	10.139558	200	9.860442	29
32	838078	221	161922	977756	422	022244	139678	200	860322	28
33	838211	221	161789	978009	422	021991	139798	200	860202	27
34	838344	221	161656	978262	422	021738	139918	200	860082	26
35	838477	221	161523	978515	422	021485	140038	200	859962	25
36	838610	221	161390	978768	422	021232	140158	200	859842	24
37	838742	221	161258	979021	422	020979	140279	201	859721	23
38	838875	221	161125	979274	422	020726	140399	201	859601	22
39	839007	221	160993	979527	422	020473	140520	201	859480	21
40	839140	220	160860	979780	422	020220	140640	201	859360	20
41	9.839272	220	10.160728	9.980033	422	10.019967	10.140761	201	9.859239	19
42	839404	220	160596	980286	422	019714	140881	201	859119	18
43	839536	220	160464	980538	422	019462	141002	201	858998	17
44	839668	220	160332	980791	421	019209	141123	201	858877	16
45	839800	220	160200	981044	421	018956	141244	202	858756	15
46	839932	220	160068	981297	421	018703	141365	202	858635	14
47	840064	219	159936	981550	421	018450	141486	202	858514	13
48	840196	219	159804	981803	421	018197	141607	202	858393	12
49	840328	219	159672	982056	421	017944	141728	202	858272	11
50	840459	219	159541	982309	421	017691	141849	202	858151	10
51	9.840591	219	10.159409	9.982562	421	10.017438	10.141971	202	9.858029	9
52	840722	219	159278	982814	421	017186	142092	202	857908	8
53	840854	219	159146	983067	421	016933	142214	202	857786	7
54	840985	219	159015	983320	421	016680	142335	203	857665	6
55	841116	218	158884	983573	421	016427	142457	203	857543	5
56	841247	218	158753	983826	421	016174	142578	203	857422	4
57	841378	218	158622	984079	421	015921	142700	203	857300	3
58	841509	218	158491	984331	421	015669	142822	203	857178	2
59	841640	218	158360	984584	421	015416	142944	203	857056	1
60	841771	218	158229	984837	421	015163	143066	203	856934	0
	Cosine.		Secant.	Cotang.		Tang.	Cosec.		Sine.	′

(44°) Logarithmic Sines.

′	Sine.	D.	Cosec.	Tang.	D.	Cotang.	Secant.	D.	Cosine.	
0	9.841771	218	10.158229	9.984837	421	10.015163	10.143066	203	9.856934	60
1	841902	218	158098	985090	421	014910	143188	203	856812	59
2	842033	218	157967	985343	421	014657	143310	204	856690	58
3	842163	217	157837	985596	421	014404	143432	204	856568	57
4	842294	217	157706	985848	421	014152	143554	204	856446	56
5	842424	217	157576	986101	421	013899	143677	204	856323	55
6	842555	217	157445	986354	421	013646	143799	204	856201	54
7	842685	217	157315	986607	421	013393	143922	204	856078	53
8	842815	217	157185	986860	421	013140	144044	204	855956	52
9	842946	217	157054	987112	421	012888	144167	204	855833	51
10	843076	217	156924	987365	421	012635	144289	205	855711	50
11	9.843206	216	10.156794	9.987618	421	10.012382	10.144412	205	9.855588	49
12	843336	216	156664	987871	421	012129	144535	205	855465	48
13	843466	216	156534	988123	421	011877	144658	205	855342	47
14	843595	216	156405	988376	421	011624	144781	205	855219	46
15	843725	216	156275	988629	421	011371	144904	205	855096	45
16	843855	216	156145	988882	421	011118	145027	205	854973	44
17	843984	216	156016	989134	421	010866	145150	205	854850	43
18	844114	215	155886	989387	421	010613	145273	206	854727	42
19	844243	215	155757	989640	421	010360	145397	206	854603	41
20	844372	215	155628	989893	421	010107	145520	206	854480	40
21	9.844502	215	10.155498	9.990145	421	10.009855	10.145644	206	9.854356	39
22	844631	215	155369	990398	421	009602	145767	206	854233	38
23	844760	215	155240	990651	421	009349	145891	206	854109	37
24	844889	215	155111	990903	421	009097	146014	206	853986	36
25	845018	215	154982	991156	421	008844	146138	206	853862	35
26	845147	215	154853	991409	421	008591	146262	206	853738	34
27	845276	214	154724	991662	421	008338	146386	207	853614	33
28	845405	214	154595	991914	421	008086	146510	207	853490	32
29	845533	214	154467	992167	421	007833	146634	207	853366	31
30	845662	214	154338	992420	421	007580	146758	207	853242	30
31	9.845790	214	10.154210	9.992672	421	10.007328	10.146882	207	9.853118	29
32	845919	214	154081	992925	421	007075	147006	207	852994	28
33	846047	214	153953	993178	421	006822	147131	207	852869	27
34	846175	214	153825	993430	421	006570	147255	207	852745	26
35	846304	214	153696	993683	421	006317	147380	207	852620	25
36	846432	213	153568	993936	421	006064	147504	208	852496	24
37	846560	213	153440	994189	421	005811	147629	208	852371	23
38	846688	213	153312	994441	421	005559	147753	208	852247	22
39	846816	213	153184	994694	421	005306	147878	208	852122	21
40	846944	213	153056	994947	421	005053	148003	208	851997	20
41	9.847071	213	10.152929	9.995199	421	10.004801	10.148128	208	9.851872	19
42	847199	213	152801	995452	421	004548	148253	208	851747	18
43	847327	213	152673	995705	421	004295	148378	208	851622	17
44	847454	212	152546	995957	421	004043	148503	209	851497	16
45	847582	212	152418	996210	421	003790	148628	209	851372	15
46	847709	212	152291	996463	421	003537	148754	209	851246	14
47	847836	212	152164	996715	421	003285	148879	209	851121	13
48	847964	212	152036	996968	421	003032	149004	209	850996	12
49	848091	212	151909	997221	421	002779	149130	209	850870	11
50	848218	212	151782	997473	421	002527	149255	209	850745	10
51	9.848345	212	10.151655	9.997726	421	10.002274	10.149381	209	9.850619	9
52	848472	211	151528	997979	421	002021	149507	210	850493	8
53	848599	211	151401	998231	421	001769	149632	210	850368	7
54	848726	211	151274	998484	421	001516	149758	210	850242	6
55	848852	211	151148	998737	421	001263	149884	210	850116	5
56	848979	211	151021	998989	421	001011	150010	210	849990	4
57	849106	211	150894	999242	421	000758	150136	210	849864	3
58	849232	211	150768	999495	421	000505	150262	210	849738	2
59	849359	211	150641	999747	421	000253	150389	210	849611	1
60	849485		150515	10.00000	421	000000	150515		849485	0
	Cosine.		Secant.	Cotang.		Tang.	Cosec.		Sine.	′

TABLE VII.

Dip of the Sea Horizon.

Height of the Eye in Feet.	Dip of the Horizon	Height of the Eye in Feet.	Dip of the Horizon
	′ ″		′ ″
1	0 59	38	6 4
2	1 24	41	6 18
3	1 42	44	6 32
4	1 58	47	6 45
5	2 12	50	6 58
6	2 25	53	7 10
7	2 36	56	7 22
8	2 47	59	7 34
9	2 57	62	7 45
10	3 07	65	7 56
11	3 16	68	8 07
12	3 25	71	8 18
13	3 33	74	8 28
14	3 41	77	8 38
15	3 49	80	8 48
16	3 56	83	8 58
17	4 04	86	9 08
18	4 11	89	9 17
19	4 17	92	9 26
20	4 24	95	9 36
21	4 31	98	9 45
22	4 37	101	9 54
23	4 43	104	10 02
24	4 49	107	10 11
25	4 55	110	10 19
26	5 01	113	10 28
27	5 07	116	10 36
28	5 13	119	10 44
29	5 18	122	10 52
30	5 24	125	11 00
31	5 29	128	11 08
32	5 34	131	11 16
33	5 39	134	11 24
34	5 44	137	11 31
35	5 49	140	11 39

TABLE VIII.

Dip of the Sea Horizon at different Distances from it.

Distance in Miles.	Height of the Eye in Feet.					
	5	10	15	20	25	30
	′	′	′	′	′	′
¼	11	22	34	45	56	68
½	6	11	17	22	28	34
¾	4	8	12	15	19	23
1	4	6	9	12	15	17
1¼	3	5	7	9	12	14
1½	2	3	4	6	8	10
2	2	3	5	6	8	10
2½	2	3	5	6	7	8
3	2	3	4	5	6	7
3½	2	3	4	5	6	6
4	2	3	4	4	5	6
5	2	3	4	4	5	5
6	2	3	4	4	5	5

TABLE IX.

Mean Refraction of Celestial Objects.

Alt.	Refr.	Alt.	Refr.	Alt.	Refr.	Alt.	Refr.	Alt.	Refr.	Alt.	Refr.
° ′	′ ″	° ′	′ ″	° ′	′ ″	° ′	′ ″	° ′	′ ″	°	″
0 0	33 0	5 0	9 54	10 0	5 15	20 0	2 35	3220	1 30	67	24
5	32 10	5	9 46	10	5 10	10	2 34	40	1 29	68	23
10	31 22	10	9 38	20	5 05	20	2 32	33 0	1 28	69	22
15	30 36	15	9 30	30	5 00	30	2 31	20	1 26	70	21
20	29 50	20	9 23	40	4 56	40	2 29	40	1 25	71	19
25	29 06	25	9 15	50	4 51	50	2 28	34 0	1 24	72	18
30	28 23	30	9 08	11 0	4 47	21 0	2 27	20	1 23	73	17
35	27 41	35	9 01	10	4 43	10	2 26	40	1 22	74	16
40	27 00	40	8 54	20	4 39	20	2 25	35 0	1 21	75	15
45	26 20	45	8 47	30	4 34	30	2 24	20	1 20	76	14
50	25 42	50	8 41	40	4 31	40	2 23	40	1 19	77	13
55	25 05	55	8 34	50	4 27	50	2 21	36 0	1 18	78	12
1 0	24 29	6 0	8 28	12 0	4 23	22 0	2 20	30	1 17	79	11
5	23 54	5	8 21	10	4 20	10	2 19	37 0	1 16	80	10
10	23 20	10	8 15	20	4 16	20	2 18	30	1 14	81	9
15	22 47	15	8 09	30	4 13	30	2 17	38 0	1 13	82	8
20	22 15	20	8 03	40	4 09	40	2 16	30	1 11	83	7
25	21 44	25	7 57	50	4 06	50	2 15	39 0	1 10	84	6
30	21 15	30	7 51	13 0	4 03	23 0	2 14	30	1 09	85	5
35	20 46	35	7 45	10	4 00	10	2 13	40 0	1 08	86	4
40	20 18	40	7 40	20	3 57	20	2 12	30	1 07	87	3
45	19 51	45	7 35	30	3 54	30	2 11	41 0	1 05	88	2
50	19 25	50	7 30	40	3 51	40	2 10	30	1 04	89	1
55	19 00	55	7 25	50	3 48	50	2 09	42 0	1 03	90	0
2 0	18 35	7 0	7 20	14 0	3 45	24 0	2 08	30	1 02		
5	18 11	5	7 15	10	3 43	10	2 07	43 0	1 01		
10	17 48	10	7 11	20	3 40	20	2 06	30	1 00		
15	17 26	15	7 06	30	3 38	30	2 05	44 0	0 59		
20	17 04	20	7 02	40	3 35	40	2 04	30	0 58		
25	16 44	25	6 57	50	3 33	50	2 03	45 0	0 57		
30	16 24	30	6 53	15 0	3 30	25 0	2 02	30	0 56		
35	16 04	35	6 49	10	3 28	10	2 01	46 0	0 55		
40	15 45	40	6 45	20	3 26	20	2 00	30	0 54		
45	15 27	45	6 41	30	3 24	30	1 59	47 0	0 53		
50	15 09	50	6 37	40	3 21	40	1 58	30	0 52		
55	14 52	55	6 33	50	3 19	50	1 57	48 0	0 51		
3 0	14 36	8 0	6 29	16 0	3 17	26 0	1 56	30	0 50		
5	14 20	5	6 25	10	3 15	10	1 55	49 0	0 49		
10	14 04	10	6 22	20	3 12	20	1 55	30	0 49		
15	13 39	15	6 18	30	3 10	30	1 54	50 0	0 48		
20	13 34	20	6 15	40	3 08	40	1 53	30	0 47		
25	13 20	25	6 11	50	3 06	50	1 52	51 0	0 46		
30	13 06	30	6 08	17 0	3 04	27 0	1 51	30	0 45		
35	12 53	35	6 05	10	3 03	15	1 50	52 0	0 44		
40	12 40	40	6 01	20	3 01	30	1 49	30	0 44		
45	12 27	45	5 58	30	2 59	45	1 48	53 0	0 43		
50	12 15	50	5 55	40	2 57	28 0	1 47	30	0 42		
55	12 03	55	5 52	50	2 55	15	1 46	54 0	0 41		
4 0	11 51	9 0	5 48	18 0	2 54	30	1 45	55	0 40		
5	11 40	5	5 45	10	2 52	45	1 44	56 0	0 38		
10	11 29	10	5 42	20	2 51	29 0	1 42	57 0	0 37		
15	11 18	15	5 39	30	2 49	20	1 41	58 0	0 35		
20	11 08	20	5 36	40	2 47	40	1 40	59	0 34		
25	10 58	25	5 34	50	2 46	30 0	1 38	60 0	0 33		
30	10 48	30	5 31	19 0	2 44	20	1 37	61 0	0 32		
35	10 39	35	5 28	10	2 43	40	1 36	62 0	0 30		
40	10 29	40	5 25	20	2 41	31 0	1 35	63 0	0 29		
45	10 20	45	5 23	30	2 40	20	1 33	64 0	0 28		
50	10 11	50	5 20	40	2 38	40	1 32	65 0	0 26		
55	10 02	55	5 18	50	2 37	32 0	1 31	66 0	0 25		

TABLE X.

$\odot^{s}$ Parallax in Altitude.

Alt.	Par^{x}.
°	″
0	9
3	9
6	9
9	9
12	9
15	8
18	8
21	8
24	8
27	8
30	8
33	7
36	7
39	7
42	6
44	6
48	6
51	5
54	5
57	5
60	4
63	4
66	4
69	3
72	3
75	2
78	2
81	1
84	1
90	0

TABLE XI.

To correct the Mean Refraction.

Altitude.	Height of Thermometer.											
	26° + 74° −	28° + 72° −	30° + 70° −	32° + 68° −	34° + 66° −	36° + 64° −	38° + 62° −	40° + 60° −	42° + 58° −	44° + 56° −	46° + 54° −	48° + 52° −	50° 50° −
6°	27″	25″	23″	21″	18″	16″	14″	11″	9″	7″	5″	2″	0″
7	23	21	20	18	16	14	12	10	8	6	4	2	0
8	20	19	17	15	14	12	10	8	7	5	3	2	0
10	16	15	14	12	11	10	8	7	6	4	3	1	0
12	13	12	11	10	9	8	7	6	4	3	2	1	0
15	11	10	9	8	7	6	5	4	4	3	2	1	0
18	9	8	7	7	6	5	4	4	3	2	1	1	0
21	7	7	6	5	5	4	4	3	2	2	1	1	0
30	5	4	4	4	3	3	2	2	2	1	1	0	0
50	2	2	2	2	2	1	1	1	1	1	0	0	0
60	2	1	1	1	1	1	1	1	1	0	0	0	0
				−	−	−	−	−	−	−	−	−	
				28·4	28·5	28·7	28·8	28·9	29·0	29·1	29·3	29·4	29·6
					+	+	+	+	+	+	+	+	
				30·9	30·6	30·4	30·4	30·2	30·1	30·0	29·8	29·7	29·6

Height of Barometer.

TABLE XII.

Reduction of ☽'s Equatorial Parallax.

Lat.	Horizontal Parallax.				
	54′	56′	58′	60′	62′
°					
0	0·0″	0·0″	0·0″	0·0″	0·0″
8	0·2	0·2	0·2	0·2	0·2
16	0·8	0·8	0·9	0·9	0·9
20	1·3	1·3	1·4	1·4	1·5
24	1·8	1·9	1·9	2·0	2·0
28	2·4	2·5	2·6	2·6	2·7
32	3·0	3·1	3·3	3·4	3·5
36	3·7	3·9	4·0	4·1	4·3
40	4·5	4·6	4·8	5·0	5·1
44	5·2	5·4	5·6	5·8	6·0
48	6·0	6·2	6·3	6·6	6·8
52	6·7	7·0	7·2	7·4	7·6
56	7·4	7·7	8·0	8·2	8·5
60	8·1	8·4	8·7	9·0	9·3
64	8·7	9·1	9·4	9·7	10·0
68	9·3	9·6	10·0	10·3	10·6
72	9·8	10·1	10·4	10·8	11·2
76	10·2	10·6	10·9	11·3	11·7
84	10·7	11·1	11·5	11·9	12·0
90	10·8	11·2	11·6	12·0	12·4

TABLE XIII.

Reduction of Latitude.

Lat.	Cor.	Lat.	Cor.
°	′ ″	°	′ ″
0	0 0·0	45	11 27·3
2	0 47·8	46	11 27·3
4	1 35·4	48	11 24·0
6	2 22·5	50	11 17·0
8	3 8·9	52	11 7·6
10	3 54·5	54	10 54·7
12	4 38·8	56	10 38·3
14	5 21·8	58	10 18·9
16	6 3·4	60	9 56·4
18	6 43·1	62	9 31·1
20	7 20·9	64	9 2·9
22	7 56·4	66	8 32·0
24	8 29·8	68	7 58·8
26	9 0·7	70	7 23·1
28	9 28·9	72	6 45·3
30	9 54·1	74	6 5·4
32	10 17·1	76	5 23·8
34	10 36·7	78	4 40·6
36	10 53·3	80	3 55·9
38	11 6·6	82	3 10·1
40	11 16·2	84	2 23·5
42	11 23·1	86	1 36·0
44	11 27·1	88	0 48·2
45	11 27·3	90	0 0·0

TABLE XIV.

Augmentation of ☽'s Semidiameter.

☽'s Alt.	Moon's Semidiameter.							
	14′ 30″	14′ 50″	15′ 10″	15′ 30″	15′ 50″	16′ 10″	16′ 30″	16′ 45″
°								
0	0·0″	0·0″	0·0″	0·0″	0·0″	0·0″	0·0″	0·0″
3	0·7	0·7	0·8	0·8	0·8	0·9	0·9	1·0
6	1·4	1·4	1·5	1·6	1·6	1·7	1·8	1·9
9	2·1	2·2	2·3	2·4	2·5	2·6	2·7	2·8
12	2·8	2·9	3·1	3·2	3·3	3·4	3·6	3·8
15	3·5	3·6	3·8	4·0	4·1	4·3	4·5	4·7
18	4·2	4·4	4·6	4·8	5·0	5·2	5·4	5·6
21	4·9	5·1	5·3	5·5	5·7	6·0	6·3	6·5
24	5·5	5·7	6·0	6·3	6·6	6·8	7·1	7·4
27	6·2	6·4	6·7	7·0	7·3	7·6	8·0	8·2
30	6·8	7·1	7·4	7·7	8·0	8·4	8·8	9·0
33	7·4	7·7	8·1	8·4	8·7	9·1	9·5	9·8
36	8·0	8·3	8·7	9·1	9·5	9·9	10·3	10·6
39	8·5	8·9	9·3	9·7	10·1	10·5	11·0	11·3
42	9·1	9·5	9·9	10·4	10·9	11·3	11·8	12·1
45	9·6	10·0	10·5	10·9	11·4	11·9	12·4	12·8
48	10·1	10·5	11·0	11·5	12·0	12·5	13·0	13·5
51	10·6	11·1	11·6	12·1	12·6	13·1	13·6	14·1
54	11·0	11·5	12·0	12·5	13·0	13·6	14·2	14·6
57	11·4	11·9	12·4	12·9	13·5	14·1	14·8	15·2
60	11·7	12·2	12·8	13·4	14·0	14·6	15·2	15·9
66	12·4	13·0	13·5	14·1	14·7	15·4	16·0	16·5
75	13·1	13·7	14·3	14·9	15·6	16·3	17·0	17·5
90	13·5	14·2	14·9	15·5	16·2	16·9	17·6	18·1

TABLE XV.

Contraction of Semidiameters of ⊙ and ☽ from Refraction.

Inclin. of Semid. to Horizon.	App. Alt. of ⊙ or ☽.						
	° 7	° 10	° 12	° 14	° 20	° 32	° 90
°	″	″	″	″	″	″	″
0	0	0	0	0	0	0	0
9	1	0	0	0	0	0	0
15	2	1	0	0	0	0	0
24	3	1	1	1	0	0	0
30	4	2	1	1	1	0	0
36	5	3	2	1	1	0	0
42	6	4	2	2	1	0	0
48	8	4	3	2	1	0	0
57	9	5	4	3	1	1	0
60	11	6	4	3	2	1	0
66	12	6	5	3	2	1	0
72	13	7	5	4	2	1	0
90	14	8	5	4	2	1	0

TABLE XVI.

⊙'s Semidiameter.

Days.	Jan.	July.
	′ ″	′ ″
1	16 18	15 46
11	16 17	15 46
21	16 17	15 46
	Feb.	August.
1	16 15	15 47
11	16 13	15 49
21	16 11	15 51
	March.	Sept.
1	16 10	15 53
11	16 7	15 56
21	16 4	15 58
	April.	Oct.
1	16 1	16 1
11	15 58	16 3
21	15 55	16 7
	May.	Nov.
1	15 53	16 9
11	15 51	16 12
21	15 49	16 14
	June.	Dec.
1	15 48	16 16
11	15 46	16 17
21	15 46	16 18

TABLE XVII.

Correction of the Time of ☽'s Meridian Passage.

Long.	Daily Variation of ☽'s Meridian Passage.									
	m 39	m 42	m 45	m 48	m 51	m 54	m 57	m 60	m 63	m 66
°	m	m	m	m	m	m	m	m	m	m
10	1	1	1	1	1	1	2	2	2	2
20	2	2	2	3	3	3	3	3	3	4
30	3	3	3	4	4	4	5	5	5	5
40	4	5	5	5	5	6	6	7	7	7
50	5	6	6	6	7	7	8	8	8	9
60	6	7	7	8	8	9	9	10	10	11
70	7	8	8	9	10	10	11	11	12	12
80	8	9	10	10	11	12	12	13	13	14
90	10	10	11	12	12	13	14	14	15	16
100	11	11	12	13	14	14	15	16	17	18
110	12	12	13	14	15	16	17	18	18	19
120	13	13	15	15	16	17	18	19	20	21
130	14	15	16	17	18	19	20	21	22	23
140	15	16	17	18	19	20	21	22	23	25
150	16	17	18	19	21	22	23	24	25	26
160	17	18	19	21	22	23	24	26	27	28
170	18	19	21	22	23	24	26	27	28	30
180	19	20	22	23	25	26	27	29	30	32

To Compute the Equation of Equal Altitudes.

Interval.	Log. A.	Log. B.	Interval.	Log. A.	Log. B.	Interval.	Log. A.	Log. B.	Interval.	Log. A.	Log. B.
h m			h m			h m			h m		
2 0	7·7297	7·7146	4 0	7·7447	7·6823	6 0	7·7703	7·6198	8 0	7·8072	7·5062
2	·7298	·7143	2	·7451	·6815	2	·7708	·6184	2	·8079	·5036
4	·7300	·7139	4	·7454	·6807	4	·7713	·6170	4	·8086	·5010
6	·7302	·7136	6	·7458	·6800	6	·7719	·6156	6	·8094	·4983
8	·7304	·7132	8	·7461	·6792	8	·7724	·6142	8	·8101	·4957
10	·7305	·7128	10	·7464	·6784	10	·7729	·6127	10	·8108	·4930
12	·7307	·7125	12	·7468	·6776	12	·7735	·6113	12	·8116	·4902
14	·7309	·7121	14	·7472	·6768	14	·7740	·6098	14	·8123	·4874
16	·7311	·7117	16	·7475	·6759	16	·7745	·6083	16	·8130	·4846
18	·7313	·7113	18	·7479	·6751	18	·7751	·6068	18	·8138	·4818
20	·7315	·7109	20	·7482	·6743	20	·7756	·6053	20	·8145	·4789
22	·7317	·7105	22	·7486	·6734	22	·7762	·6038	22	·8153	·4760
24	·7319	·7101	24	·7490	·6726	24	·7767	·6023	24	·8160	·4731
26	·7321	·7097	26	·7494	·6717	26	·7773	·6007	26	·8168	·4701
28	·7323	·7092	28	·7497	·6708	28	·7779	·5991	28	·8176	·4671
30	·7325	·7088	30	·7501	·6700	30	·7784	·5975	30	·8183	·4640
32	·7327	·7083	32	·7505	·6691	32	·7790	·5959	32	·8191	·4609
34	·7329	·7079	34	·7509	·6682	34	·7796	·5943	34	·8199	·4578
36	·7331	·7075	36	·7513	·6673	36	·7801	·5927	36	·8206	·4546
38	·7333	·7070	38	·7517	·6663	38	·7807	·5910	38	·8214	·4514
40	·7336	·7065	40	·7521	·6654	40	·7813	·5894	40	·8222	·4482
42	·7338	·7061	42	·7525	·6645	42	·7819	·5877	42	·8230	·4449
44	·7340	·7056	44	·7529	·6635	44	·7825	·5860	44	·8238	·4415
46	·7342	·7051	46	·7533	·6626	46	·7831	·5843	46	·8246	·4381
48	·7345	·7046	48	·7537	·6616	48	·7836	·5825	48	·8254	·4347
50	·7347	·7041	50	·7541	·6606	50	·7842	·5808	50	·8262	·4312
52	·7349	·7036	52	·7545	·6597	52	·7848	·5790	52	·8270	·4277
54	·7352	·7031	54	·7549	·6587	54	·7854	·5772	54	·8278	·4241
56	·7354	·7026	56	·7553	·6577	56	·7860	·5754	56	·8286	·4205
58	·7357	·7021	58	·7557	·6567	58	·7867	·5736	58	·8294	·4168
3 0	·7359	·7015	5 0	·7562	·6556	7 0	·7873	·5717	9 0	·8302	·4131
2	·7362	·7010	2	·7566	·6546	2	·7879	·5699	2	·8311	·4093
4	·7364	·7005	4	·7570	·6536	4	·7885	·5680	4	·8319	·4055
6	·7367	·6999	6	·7575	·6525	6	·7891	·5661	6	·8328	·4016
8	·7369	·6993	8	·7579	·6514	8	·7898	·5641	8	·8336	·3977
10	·7372	·6988	10	·7583	·6504	10	·7904	·5622	10	·8344	·3937
12	·7374	·6982	12	·7588	·6493	12	·7910	·5602	12	·8353	·3896
14	·7377	·6976	14	·7592	·6482	14	·7916	·5582	14	·8361	·3855
16	·7380	·6970	16	·7597	·6471	16	·7923	·5562	16	·8370	·3813
18	·7383	·6964	18	·7601	·6460	18	·7929	·5542	18	·8378	·3771
20	·7386	·6958	20	·7606	·6448	20	·7936	·5522	20	·8387	·3728
22	·7388	·6952	22	·7610	·6437	22	·7942	·5501	22	·8396	·3684
24	·7391	·6946	24	·7615	·6425	24	·7949	·5480	24	·8404	·3639
26	·7394	·6940	26	·7620	·6414	26	·7955	·5459	26	·8413	·3594
28	·7397	·6934	28	·7624	·6402	28	·7962	·5437	28	·8422	·3548
30	·7400	·6927	30	·7629	·6390	30	·7969	·5416	30	·8430	·3501
32	·7403	·6921	32	·7634	·6378	32	·7975	·5394	32	·8439	·3454
34	·7406	·6914	34	·7638	·6366	34	·7982	·5372	34	·8448	·3406
36	·7409	·6908	36	·7643	·6354	36	·7989	·5350	36	·8457	·3357
38	·7412	·6901	38	·7648	·6342	38	·7995	·5327	38	·8466	·3307
40	·7415	·6894	40	·7653	·6329	40	·8002	·5304	40	·8475	·3256
42	·7418	·6888	42	·7658	·6317	42	·8009	·5281	42	·8484	·3205
44	·7421	·6881	44	·7663	·6304	44	·8016	·5258	44	·8493	·3152
46	·7424	·6874	46	·7668	·6291	46	·8023	·5234	46	·8502	·3099
48	·7428	·6867	48	·7673	·6278	48	·8030	·5211	48	·8511	·3045
50	·7431	·6859	50	·7678	·6265	50	·8037	·5186	50	·8520	·2989
52	·7434	·6852	52	·7683	·6252	52	·8044	·5162	52	·8530	·2933
54	·7437	·6845	54	·7688	·6239	54	·8051	·5137	54	·8539	·2876
56	·7441	·6838	56	·7693	·6225	56	·8058	·5112	56	·8548	·2817
58	·7444	·6830	58	·7698	·6212	58	·8065	·5087	58	·8558	·2758
4 0	7·7447	7·6823	6 0	7·7703	7·6198	8 0	7·8072	7·5062	10 0	7·8567	7·2697

⊙'s Declination when on the Meridian of Greenwich, for every Day in the Year 1822.

Days.	January.	February.	March.	April.	May.	June.
	South.	South.	South.	North.	North.	North.
1	23° 2′ 31″	17° 10′ 15″	7° 40′ 43″	4° 26′ 11″	14° 59′ 25″	22° 1′ 33″
2	22 57 25	16 53 5	7 17 54	4 49 17	15 17 30	22 9 39
3	22 51 52	16 35 37	6 55 00	5 12 19	15 35 21	22 17 22
4	22 45 51	16 17 52	6 31 59	5 35 15	15 52 56	22 24 41
5	22 39 24	15 59 51	6 8 53	5 58 5	16 10 16	22 31 37
6	22 32 29	15 41 33	5 45 43	6 20 48	16 27 19	22 38 10
7	22 25 8	15 22 59	5 22 27	6 43 25	16 44 6	22 44 19
8	22 17 20	15 4 9	4 59 8	7 5 56	17 0 37	22 50 4
9	22 9 6	14 45 5	4 35 44	7 28 19	17 16 51	22 55 25
10	22 00 27	14 25 45	4 12 17	7 50 35	17 32 47	23 0 22
11	21 51 21	14 6 11	3 48 47	8 12 43	17 48 26	23 4 55
12	21 41 50	13 46 23	3 25 14	8 34 43	18 3 47	23 9 3
13	21 31 53	13 26 21	3 1 38	8 56 34	18 18 50	23 12 47
14	21 21 32	13 6 6	2 38 1	9 18 17	18 33 35	23 16 6
15	21 10 46	12 45 38	2 14 21	9 39 50	18 48 1	23 19 1
16	20 59 35	12 24 58	1 50 41	10 1 14	19 2 9	23 21 31
17	20 48 1	12 4 6	1 26 59	10 22 28	19 15 57	23 23 37
18	20 36 2	11 43 2	1 3 17	10 43 32	19 29 26	23 25 18
19	20 23 41	11 21 47	0 39 34	11 4 26	19 42 35	23 26 34
20	20 10 56	11 0 22	0 15 51 S	11 25 9	19 55 23	23 27 25
21	19 57 48	10 38 46	0 7 51 N	11 45 41	20 7 52	23 27 51
22	19 44 18	10 17 1	0 31 32	12 6 1	20 20 00	23 27 52
23	19 30 26	9 55 6	0 55 12	12 26 9	20 31 47	23 27 29
24	19 16 13	9 33 2	1 18 50	12 46 5	20 43 13	23 26 40
25	19 1 38	9 10 48	1 42 26	13 5 48	20 54 18	23 25 27
26	18 46 42	8 48 28	2 6 0	13 25 19	21 5 1	23 23 50
27	18 31 26	8 26 1	2 29 31	13 44 36	21 15 22	23 21 47
28	18 15 50	8 3 25	2 52 59	14 3 39	21 25 21	23 19 20
29	17 59 55		3 16 23	14 22 29	21 34 58	23 16 29
30	17 43 40		3 39 43	14 41 4	21 44 12	23 13 13
31	17 27 6		4 3 00		21 53 4	

Days.	July.	August.	September.	October.	November.	December.
	North.	North.	North.	South.	South.	South.
1	23° 9′ 32″	18° 7′ 52″	8° 24′ 58″	3° 4′ 6″	14° 21′ 30″	21° 47′ 24″
2	23 5 27	17 52 42	8 3 9	3 27 25	14 40 42	21 56 38
3	23 0 58	17 37 16	7 41 12	3 50 42	14 59 41	22 5 26
4	22 56 5	17 21 32	7 19 8	4 13 56	15 18 24	22 13 50
5	22 50 48	17 5 31	6 56 57	4 37 7	15 36 53	22 21 47
6	22 45 7	16 49 13	6 34 38	5 0 15	15 55 7	22 29 19
7	22 39 3	16 32 39	6 12 13	5 23 19	16 13 4	22 36 24
8	22 32 35	16 15 49	5 49 42	5 46 19	16 30 45	22 43 2
9	22 25 43	15 58 43	5 27 5	6 9 15	16 48 10	22 49 14
10	22 18 28	15 41 22	5 4 22	6 32 7	17 5 18	22 54 58
11	22 10 50	15 23 45	4 41 33	6 54 53	17 22 8	23 0 16
12	22 2 49	15 5 53	4 18 40	7 17 34	17 38 40	23 5 6
13	21 54 26	14 47 47	3 55 42	7 40 8	17 54 54	23 9 29
14	21 45 40	14 29 27	3 32 40	8 2 37	18 10 49	23 13 23
15	21 36 31	14 10 52	3 9 34	8 24 59	18 26 25	23 16 51
16	21 27 0	13 52 4	2 46 24	8 47 13	18 41 41	23 19 50
17	21 17 7	13 33 3	2 23 11	9 9 20	18 56 37	23 22 21
18	21 6 53	13 13 49	1 59 56	9 31 20	19 11 13	23 24 24
19	20 56 17	12 54 22	1 36 38	9 53 10	19 25 29	23 25 58
20	20 45 20	12 34 43	1 13 17	10 14 52	19 39 23	23 27 5
21	20 34 1	12 14 52	0 49 55	10 36 25	19 52 56	23 27 43
22	20 22 23	11 54 49	0 26 32	10 57 49	20 6 6	23 27 53
23	20 10 23	11 34 35	0 3 7 N	11 19 2	20 18 55	23 27 34
24	19 58 3	11 14 11	0 20 18 S	11 40 5	20 31 21	23 26 47
25	19 45 24	10 53 35	0 43 43	12 0 57	20 43 24	23 25 32
26	19 32 25	10 32 50	1 7 9	12 21 39	20 55 4	23 23 49
27	19 19 6	10 11 54	1 30 34	12 42 8	21 6 20	23 21 37
28	19 5 28	9 50 49	1 53 59	13 2 26	21 17 13	23 18 58
29	18 51 32	9 29 34	2 17 23	13 22 32	21 27 41	23 15 50
30	18 37 17	9 8 11	2 40 45	13 42 24	21 37 45	23 12 14
31	18 22 43	8 46 38		14 2 4		23 8 11

TABLE XIX.

⊙'s Declination when on the Meridian of Greenwich, for every Day in the Year 1823.

Days.	January.	February.	March.	April.	May.	June.
	South.	South.	South.	North.	North.	North.
1	23° 3′ 39″	17°14′23″	7°46′18″	4°20′28″	14°54′53″	21°59′27″
2	22 58 40	16 57 17	7 23 31	4 43 36	15 13 2	22 7 39
3	22 53 13	16 39 54	7 0 38	5 6 39	15 30 57	22 15 28
4	22 47 19	16 22 13	6 37 39	5 29 37	15 48 37	22 22 53
5	22 40 58	16 4 15	6 14 34	5 52 29	16 6 1	22 29 55
6	22 34 10	15 46 0	5 51 23	6 15 15	16 23 9	22 36 34
7	22 26 55	15 27 29	5 28 8	6 37 54	16 40 1	22 42 49
8	22 19 14	15 8 43	5 4 49	7 0 27	16 56 36	22 48 40
9	22 11 6	14 49 41	4 41 25	7 22 53	17 12 54	22 54 7
10	22 2 32	14 30 24	4 17 58	7 45 12	17 28 56	22 59 10
11	21 53 32	14 10 52	3 54 27	8 7 23	17 44 40	23 3 49
12	21 44 6	13 51 7	3 30 54	8 29 26	18 0 6	23 8 3
13	21 34 16	13 31 8	3 7 18	8 51 20	18 15 14	23 11 53
14	21 24 0	13 10 56	2 43 40	9 13 5	18 30 3	23 15 18
15	21 13 19	12 50 31	2 20 1	9 34 41	18 44 34	23 18 19
16	21 2 15	12 29 53	1 56 20	9 56 7	18 58 46	23 20 55
17	20 50 46	12 9 4	1 32 38	10 17 24	19 12 39	23 23 6
18	20 38 53	11 48 4	1 8 56	10 38 30	19 26 12	23 24 53
19	20 26 37	11 26 52	0 45 14	10 59 26	19 39 25	23 26 15
20	20 13 58	11 5 30	0 21 32 S	11 20 10	19 52 18	23 27 12
21	20 0 56	10 43 58	0 2 10 N	11 40 44	20 4 51	23 27 44
22	19 47 32	10 22 16	0 25 50	12 1 6	20 17 3	23 27 51
23	19 33 46	10 0 24	0 49 29	12 21 16	20 28 55	23 27 34
24	19 19 38	9 38 23	1 13 7	12 41 14	20 40 25	23 26 52
25	19 5 10	9 16 14	1 36 42	13 0 59	20 51 34	23 25 45
26	18 50 20	8 53 57	2 0 15	13 20 32	21 2 22	23 24 13
27	18 35 9	8 31 31	2 23 46	13 39 52	21 12 49	23 22 17
28	18 19 39	8 8 59	2 47 14	13 58 58	21 22 53	23 19 56
29	18 3 49		3 10 38	14 17 50	21 32 35	23 17 10
30	17 47 39		3 33 59	14 36 29	21 41 55	23 14 0
31	17 31 10		3 57 15		21 50 53	

Days.	July.	August.	September.	October.	November.	December.
	North.	North.	North.	South.	South.	South.
1	23°10′25″	18°11′29″	8°30′14″	2°58′25″	14°16′46″	21°45′ 2″
2	23 6 26	17 56 23	8 8 26	3 21 45	14 36 2	21 54 23
3	23 2 3	17 41 0	7 46 30	3 45 4	14 55 5	22 3 18
4	22 57 16	17 25 19	7 24 26	4 8 19	15 13 53	22 11 48
5	22 52 4	17 9 22	7 2 16	4 31 32	15 32 26	22 19 52
6	22 46 29	16 53 7	6 39 58	4 54 42	15 50 43	22 27 30
7	22 40 30	16 36 36	6 17 34	5 17 48	16 8 45	22 34 41
8	22 34 7	16 19 49	5 55 3	5 40 49	16 26 30	22 41 26
9	22 27 21	16 2 47	5 32 27	6 3 47	16 43 59	22 47 44
10	22 20 11	15 45 28	5 9 46	6 26 39	17 1 10	22 53 35
11	22 12 39	15 27 55	4 46 59	6 49 26	17 18 4	22 58 59
12	22 4 43	15 10 7	4 24 7	7 12 8	17 34 40	23 3 56
13	21 56 25	14 52 5	4 1 11	7 34 43	17 50 58	23 8 25
14	21 47 44	14 33 48	3 38 10	7 57 12	18 6 57	23 12 26
15	21 38 41	14 15 17	3 15 6	8 19 35	18 22 37	23 16 0
16	21 29 16	13 56 33	2 51 58	8 41 50	18 37 57	23 19 5
17	21 19 28	13 37 36	2 28 47	9 3 58	18 52 58	23 21 43
18	21 9 19	13 18 26	2 5 33	9 25 58	19 7 38	23 23 53
19	20 58 49	12 59 3	1 42 17	9 47 49	19 21 58	23 25 35
20	20 47 58	12 39 28	1 18 59	10 9 33	19 35 57	23 26 48
21	20 36 45	12 19 41	0 55 38	10 31 7	19 49 34	23 27 33
22	20 25 12	11 59 42	0 32 16	10 52 32	20 2 50	23 27 50
23	20 13 18	11 39 31	0 8 52 N	11 13 47	20 15 44	23 27 38
24	20 1 4	11 19 10	0 14 32 S	11 34 53	20 28 16	23 26 58
25	19 48 29	10 58 38	0 37 58	11 55 47	20 40 25	23 25 50
26	19 35 35	10 37 55	1 1 23	12 16 31	20 52 11	23 24 14
27	19 22 22	10 17 2	1 24 49	12 37 4	21 3 33	23 22 9
28	19 8 49	9 55 59	1 48 14	12 57 26	21 14 32	23 19 36
29	18 54 57	9 34 46	2 11 39	13 17 35	21 25 7	23 16 35
30	18 40 46	9 13 24	2 35 2	13 37 32	21 35 17	23 13 6
31	18 26 16	8 51 53		13 57 16		23 9 8

TABLE XIX.

⊙'s Declination when on the Meridian of Greenwich, for every Day in the Year 1824.

Days.	January.	February.	March.	April.	May.	June.
	South.	South.	South.	North.	North.	North.
1	23° 4′ 43″	17°18′ 20″	7° 28′ 50″	4°38′14″	15° 8′49″	22° 5′42″
2	22 59 51	17 1 18	7 5 57	5 1 19	15 26 47	22 13 37
3	22 54 30	16 43 58	6 42 58	5 24 18	15 44 30	22 21 8
4	22 48 43	16 26 20	6 19 54	5 47 12	16 1 58	22 28 15
5	22 42 28	16 8 26	5 56 45	6 9 59	16 19 9	22 34 59
6	22 35 46	15 50 16	5 33 31	6 32 40	16 36 5	22 41 19
7	22 28 37	15 31 49	5 10 12	6 55 14	16 52 43	22 47 16
8	22 21 2	15 13 6	4 46 50	7 17 41	17 9 5	22 52 48
9	22 13 1	14 54 8	4 23 24	7 40 0	17 25 10	22 57 57
10	22 4 33	14 34 55	3 59 55	8 2 12	17 40 57	23 2 41
11	21 55 40	14 15 28	3 36 23	8 24 15	17 56 26	23 7 1
12	21 46 21	13 55 47	3 12 49	8 46 10	18 11 38	23 10 56
13	21 36 36	13 35 52	2 49 13	9 7 57	18 26 31	23 14 27
14	21 26 27	13 15 43	2 25 35	9 29 34	18 41 5	23 17 34
15	21 15 53	12 55 22	2 1 56	9 51 1	18 55 21	23 20 16
16	21 4 54	12 34 49	1 38 15	10 12 20	19 9 18	23 22 33
17	20 53 32	12 14 3	1 14 34	10 33 28	19 22 55	23 24 26
18	20 41 45	11 53 6	0 50 52	10 54 26	19 36 13	23 25 53
19	20 29 35	11 31 57	0 27 11	11 15 13	19 49 11	23 26 57
20	20 17 2	11 10 37	0 3 29 S	11 35 49	20 1 49	23 27 35
21	20 4 5	10 49 7	0 20 12 N	11 56 14	20 14 6	23 27 48
22	19 50 47	10 27 27	0 43 51	12 16 27	20 26 3	23 27 37
23	19 37 6	10 5 37	1 7 30	12 36 29	20 37 39	23 27 1
24	19 23 3	9 43 37	1 31 6	12 56 18	20 48 54	23 26 0
25	19 8 39	9 21 29	1 54 41	13 15 54	20 59 47	23 24 34
26	18 53 53	8 59 13	2 18 13	13 35 18	21 10 19	23 22 43
27	18 38 47	8 36 48	2 41 43	13 54 28	21 20 29	23 20 28
28	18 23 21	8 14 16	3 5 9	14 13 25	21 30 17	23 17 48
29	18 7 34	7 51 36	3 28 31	14 32 7	21 39 42	23 14 44
30	17 51 28		3 51 50	14 50 35	21 48 45	23 11 15
31	17 35 3		4 15 5		21 57 26	

Days.	July.	August.	September.	October.	November.	December.
	North.	North.	North.	South.	South.	South.
1	23° 7′22″	18° 0′ 0″	8°13′41″	3°16′ 6″	14°31′21″	21° 52′ 6″
2	23 3 4	17 44 41	7 51 48	3 39 24	14 50 26	22 1 7
3	22 58 23	17 29 5	7 29 48	4 2 39	15 9 17	22 9 43
4	22 53 17	17 13 12	7 7 40	4 25 52	15 27 53	22 17 53
5	22 47 48	16 57 2	6 45 25	4 49 1	15 46 13	22 25 36
6	22 41 55	16 40 36	6 23 3	5 12 7	16 4 18	22 32 54
7	22 35 38	16 23 54	6 0 35	5 35 9	16 22 7	22 39 45
8	22 28 58	16 6 56	5 38 2	5 58 6	16 39 39	22 46 10
9	22 21 54	15 49 43	5 15 22	6 20 59	16 56 54	22 52 7
10	22 14 28	15 32 14	4 52 38	6 43 46	17 13 52	22 57 38
11	22 6 38	15 14 31	4 29 48	7 6 29	17 30 32	23 2 41
12	21 58 26	14 56 32	4 6 53	7 29 5	17 46 54	23 7 17
13	21 49 51	14 38 19	3 43 54	7 51 36	18 2 58	23 11 25
14	21 40 53	14 19 53	3 20 51	8 14 0	18 18 43	23 15 6
15	21 31 34	14 1 12	2 57 44	8 36 18	18 34 9	23 18 19
16	21 21 52	13 42 18	2 34 33	8 58 28	18 49 15	23 21 3
17	21 11 49	13 23 11	2 11 19	9 20 31	19 4 1	23 23 20
18	21 1 24	13 3 51	1 48 3	9 42 25	19 18 26	23 25 9
19	20 50 37	12 44 18	1 24 44	10 4 12	19 32 31	23 26 29
20	20 39 29	12 24 33	1 1 22	10 25 49	19 46 15	23 27 21
21	20 28 1	12 4 36	0 37 59	10 47 17	19 59 36	23 27 45
22	20 16 11	11 44 28	0 14 35 N	11 8 36	20 12 36	23 27 40
23	20 4 2	11 24 8	0 8 50 S	11 29 45	20 25 14	23 27 7
24	19 51 32	11 3 37	0 32 16	11 50 43	20 37 28	23 26 6
25	19 38 42	10 42 56	0 55 43	12 11 30	20 49 20	23 24 36
26	19 25 32	10 22 5	1 19 9	12 32 6	21 0 48	23 22 38
27	19 12 4	10 1 3	1 42 35	12 52 31	21 11 53	23 20 12
28	18 58 16	9 39 53	2 6 0	13 12 43	21 22 33	23 17 17
29	18 44 9	9 18 33	2 29 24	13 32 42	21 32 49	23 13 55
30	18 29 44	8 57 4	2 52 46	13 52 29	21 42 40	23 10 5
31	18 15 1	8 35 27		14 12 2		23 5 47

TABLE XIX.

⊙'s Declination when on the Meridian of Greenwich, for every Day in the Year 1825.

Days.	January.	February.	March.	April.	May.	June.
	South.	South.	South.	North.	North.	North.
1	23° 0′ 59″	17° 5′ 26″	7° 34′ 19″	4° 32′ 36″	15° 4′ 19″	22° 3′ 37″
2	22 55 46	16 48 11	7 11 29	4 55 40	15 22 20	22 11 36
3	22 50 5	16 30 39	6 48 33	5 18 40	15 40 6	22 19 13
4	22 43 58	16 12 49	6 25 32	5 41 34	15 57 37	22 26 26
5	22 37 23	15 54 43	6 2 25	6 4 22	16 14 52	22 33 16
6	22 30 21	15 36 21	5 39 13	6 27 3	16 31 51	22 39 42
7	22 22 52	15 17 42	5 15 56	6 49 38	16 48 33	22 45 44
8	22 14 58	14 58 48	4 52 35	7 12 7	17 4 59	22 51 23
9	22 6 37	14 39 39	4 29 11	7 34 28	17 21 8	22 56 37
10	21 57 50	14 20 15	4 5 43	7 56 42	17 37 0	23 1 28
11	21 48 37	14 0 37	3 42 12	8 18 48	17 52 34	23 5 54
12	21 38 58	13 40 45	3 18 38	8 40 46	18 7 50	23 9 55
13	21 28 55	13 20 39	2 55 1	9 2 35	18 22 48	23 13 33
14	21 18 27	13 0 20	2 31 23	9 24 15	18 37 28	23 16 45
15	21 7 34	12 39 49	2 7 43	9 45 46	18 51 49	23 19 33
16	20 56 16	12 19 5	1 44 1	10 7 7	19 5 51	23 21 57
17	20 44 35	11 58 9	1 20 19	10 28 19	19 19 34	23 23 56
18	20 32 30	11 37 2	0 56 37	10 49 20	19 32 57	23 25 30
19	20 20 2	11 15 44	0 32 54	11 10 10	19 46 0	23 26 39
20	20 7 11	10 54 16	0 9 12 S	11 30 50	19 58 43	23 27 23
21	19 53 57	10 32 38	0 14 30 N	11 51 18	20 11 6	23 27 42
22	19 40 21	10 10 50	0 38 11	12 11 34	20 23 8	23 27 37
23	19 26 23	9 48 53	1 1 50	12 31 39	20 34 48	23 27 7
24	19 12 4	9 26 47	1 25 27	12 51 31	20 46 8	23 26 12
25	18 57 23	9 4 33	1 49 2	13 11 10	20 57 7	23 24 52
26	18 42 22	8 42 10	2 12 35	13 30 36	21 7 43	23 23 8
27	18 27 1	8 19 40	2 36 5	13 49 49	21 17 58	23 20 59
28	18 11 20	7 57 3	2 59 31	14 8 48	21 27 51	23 18 25
29	17 55 19		3 22 53	14 27 33	21 37 21	23 15 27
30	17 39 0		3 46 12	14 46 3	21 46 29	23 12 4
31	17 22 21		4 9 26		21 55 15	

Days.	July.	August.	September.	October.	November.	December.
	North.	North.	North.	South.	South.	South.
1	23° 8′ 17″	18° 3′ 41″	8° 19′ 2″	3° 10′ 24″	14° 26′ 40″	21° 49′ 48″
2	23 4 6	17 48 27	7 57 11	3 33 43	14 45 48	21 58 55
3	22 59 30	17 32 56	7 35 12	3 56 59	15 4 43	22 7 37
4	22 54 31	17 17 7	7 13 6	4 20 12	15 23 23	22 15 54
5	22 49 8	17 1 1	6 50 52	4 43 23	15 41 47	22 23 44
6	22 43 20	16 44 39	6 28 32	5 6 31	15 59 57	22 31 8
7	22 37 9	16 28 1	6 6 5	5 29 34	16 17 50	22 38 6
8	22 30 35	16 11 6	5 43 32	5 52 33	16 35 27	22 44 37
9	22 23 37	15 53 56	5 20 53	6 15 28	16 52 47	22 50 41
10	22 16 16	15 36 30	4 58 8	6 38 18	17 9 50	22 56 19
11	22 8 32	15 18 49	4 35 18	7 1 3	17 26 35	23 1 28
12	22 0 25	15 0 53	4 12 23	7 23 42	17 43 2	23 6 11
13	21 51 55	14 42 43	3 49 24	7 46 15	17 59 11	23 10 26
14	21 43 3	14 24 19	3 26 21	8 8 42	18 15 0	23 14 13
15	21 33 48	14 5 41	3 3 14	8 31 2	18 30 31	23 17 32
16	21 24 11	13 46 50	2 40 4	8 53 14	18 45 41	23 20 24
17	21 14 12	13 27 45	2 16 50	9 15 19	19 0 32	23 22 47
18	21 3 52	13 8 28	1 53 34	9 37 15	19 15 2	23 24 42
19	20 53 11	12 48 58	1 30 16	9 59 3	19 29 11	23 26 9
20	20 42 9	12 29 16	1 6 56	10 20 42	19 42 59	23 27 8
21	20 30 45	12 9 22	0 43 34	10 42 12	19 56 25	23 27 38
22	20 19 0	11 49 17	0 20 11 N	11 3 32	20 9 30	23 27 40
23	20 6 55	11 29 1	0 3 13 S	11 24 42	20 22 12	23 27 14
24	19 54 31	11 8 34	0 26 38	11 45 42	20 34 31	23 26 19
25	19 41 47	10 47 56	0 50 3	12 6 31	20 46 28	23 24 57
26	19 28 43	10 27 8	1 13 29	12 27 9	20 58 1	23 23 5
27	19 15 19	10 6 10	1 36 54	12 47 35	21 9 11	23 20 46
28	19 1 36	9 45 3	2 0 18	13 7 50	21 19 57	23 17 59
29	18 47 35	9 23 46	2 23 41	13 27 52	21 30 19	23 14 43
30	18 33 15	9 2 20	2 47 4	13 47 41	21 40 16	23 11 0
31	18 18 37	8 40 46		14 7 17		23 6 49

To reduce ⊙'s Declination from Table XIX. to the Noon of any Day, Greenwich time, till the Year 1886.

It may also be used to reduce the Equation of Time, from Table XXII. to subsequent Years.

Periods of 4 Years.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Years.															
1822	1826	1830	1834	1838	1842	1846	1850	1854	1858	1862	1866	1870	1874	1878	1882
1823	1827	1831	1835	1839	1843	1847	1851	1855	1859	1863	1867	1871	1875	1879	1883
1824	1828	1832	1836	1840	1844	1848	1852	1856	1860	1864	1868	1872	1876	1880	1884
1825	1829	1833	1837	1841	1845	1849	1853	1857	1861	1865	1869	1873	1877	1881	1885

Add the Correction from Part I. when the Declination from Table XIX. is *increasing*.
Substract . . . . . *decreasing*.

Daily Diff. of ⊙'s Declin.	0′	0″	0′	0″	0′	1″	0′	1″	0′	2″	0′	2″	0′	2″	0′	3″	0′	3″	0′	3″	0′	4″	0′	4″	0′	5″
0′ 10″	0	0	0	0	0	1	0	1	0	2	0	2	0	2	0	3	0	3	0	3	0	4	0	4	0	5
0 20	0	0	0	1	0	1	0	2	0	3	0	4	0	4	0	5	0	6	0	7	0	8	0	9	0	9
0 30	0	0	0	1	0	2	0	3	0	4	0	5	0	6	0	7	0	8	0	9	0	10	0	11	0	12	0	13	0	14
0 40	0	0	0	1	0	2	0	4	0	5	0	6	0	7	0	8	0	10	0	11	0	12	0	14	0	15	0	16	0	17	0	18
0 50	0	0	0	2	0	3	0	5	0	6	0	8	0	9	0	11	0	12	0	14	0	15	0	17	0	18	0	20	0	21	0	23
1 0	0	0	0	2	0	4	0	6	0	7	0	9	0	11	0	13	0	15	0	17	0	19	0	20	0	22	0	24	0	26	0	28
2 0	0	0	0	4	0	8	0	11	0	15	0	19	0	22	0	25	0	30	0	33	0	37	0	41	0	44	0	48	0	51	0	55
3 0	0	0	0	6	0	11	0	17	0	22	0	28	0	33	0	39	0	44	0	50	0	55	1	1	1	6	1	12	1	17	1	23
4 0	0	0	0	7	0	15	0	22	0	30	0	37	0	44	0	52	0	59	1	7	1	14	1	21	1	29	1	36	1	43	1	51
5 0	0	0	0	9	0	18	0	28	0	37	0	46	0	55	1	5	1	14	1	23	1	32	1	42	1	51	2	0	2	9	2	19
6 0	0	0	0	11	0	22	0	33	0	44	0	55	1	6	1	18	1	29	1	40	1	51	2	2	2	13	2	24	2	35	2	46
7 0	0	0	0	13	0	26	0	39	0	52	1	5	1	18	1	31	1	43	1	56	2	9	2	22	2	35	2	48	3	1	3	14
8 0	0	0	0	15	0	30	0	44	0	59	1	14	1	29	1	43	1	58	2	13	2	28	2	42	2	57	3	12	3	27	3	42
9 0	0	0	0	17	0	33	0	50	1	6	1	23	1	40	1	56	2	13	2	30	2	46	3	3	3	19	3	36	3	53	4	9
10 0	0	0	0	18	0	37	0	55	1	14	1	32	1	51	2	9	2	28	2	46	3	5	3	23	3	42	4	0	4	19	4	37
20 0	0	0	0	37	1	13	1	51	2	27	3	5	3	41	4	19	4	56	5	32	6	9	6	46	7	23	8	0	8	37	9	14

Correction — Part I.

Substract the Correction from Part II. whether the Declination from Table XIX. is *increasing* or *decreasing*.

Daily Diff. of ⊙'s Declin.	0″	2″	4″	6″	8″	10″	12″	14″	16″	18″	20″	22″	24″	26″	28″	30″
1′	0	2	4	6	7	9	11	13	15	17	19	21	24	26	27	29
7	0	1	3	4	5	6	8	10	11	12	14	16	18	20	21	23
13	0	1	2	3	5	6	7	9	10	11	12	13	14	15	17	18
19	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
21	0	1	2	2	3	4	5	6	7	8	9	10	11	11	12	13
23	0	0	1	1	1	2	2	3	3	3	4	4	4	5	5	6

Correction — Part II.

TABLE XXI.

⊙'s Right Ascension when on the Meridian of Greenwich, for every Day in the Year 1822.

Days.	January.			February.			March.			April.			May.			June.		
	h	m	s	h	m	s	h	m	s	h	m	s	h	m	s	h	m	s
1	18	46	6	20	58	28	22	47	37	0	41	11	2	32	21	4	34	58
2	18	50	32	21	2	33	22	51	22	0	44	49	2	36	9	4	39	3
3	18	54	56	21	6	36	22	55	6	0	48	27	2	39	59	4	43	9
4	18	59	20	21	10	38	22	58	49	0	52	6	2	43	49	4	47	15
5	19	3	44	21	14	40	23	2	32	0	55	44	2	47	39	4	51	22
6	19	8	7	21	18	41	23	6	14	0	59	23	2	51	30	4	55	29
7	19	12	30	21	22	41	23	9	56	1	3	2	2	55	22	4	59	36
8	19	16	52	21	26	40	23	13	38	1	6	41	2	59	14	5	3	43
9	19	21	14	21	30	38	23	17	19	1	10	21	3	3	7	5	7	51
10	19	25	35	21	34	36	23	21	0	1	14	0	3	7	0	5	11	59
11	19	29	56	21	38	33	23	24	40	1	17	40	3	10	54	5	16	8
12	19	34	16	21	42	29	23	28	21	1	21	20	3	14	49	5	20	16
13	19	38	35	21	46	24	23	32	1	1	25	1	3	18	44	5	24	25
14	19	42	54	21	50	19	23	35	40	1	28	42	3	22	40	5	28	34
15	19	47	13	21	54	13	23	39	20	1	32	23	3	26	36	5	32	44
16	19	51	30	21	58	6	23	42	59	1	36	5	3	30	33	5	36	53
17	19	55	47	22	1	58	23	46	38	1	39	47	3	34	31	5	41	3
18	20	0	3	22	5	50	23	50	17	1	43	29	3	38	29	5	45	12
19	20	4	19	22	9	41	23	53	55	1	47	12	3	42	28	5	49	22
20	20	8	33	22	13	32	23	57	34	1	50	55	3	46	27	5	53	32
21	20	12	47	22	17	22	0	1	12	1	54	39	3	50	27	5	57	41
22	20	17	1	22	21	11	0	4	51	1	58	23	3	54	27	6	1	51
23	20	21	13	22	24	59	0	8	29	2	2	7	3	58	28	6	6	1
24	20	25	25	22	28	47	0	12	7	2	5	52	4	2	30	6	10	10
25	20	29	36	22	32	34	0	15	45	2	9	38	4	6	31	6	14	20
26	20	33	46	22	36	21	0	19	23	2	13	24	4	10	34	6	18	29
27	20	37	55	22	40	7	0	23	1	2	17	10	4	14	37	6	22	38
28	20	42	3	22	43	52	0	26	39	2	20	57	4	18	40	6	26	47
29	20	46	11				0	30	17	2	24	44	4	22	44	6	30	56
30	20	50	18				0	33	55	2	28	32	4	26	48	6	35	4
31	20	54	23				0	37	33				4	30	53			

Days.	July.			August.			September.			October.			November.			December.		
	h	m	s	h	m	s	h	m	s	h	m	s	h	m	s	h	m	s
1	6	39	13	8	44	8	10	40	17	12	28	22	14	24	33	16	28	16
2	6	43	21	8	48	1	10	43	55	12	32	0	14	28	28	16	32	35
3	6	47	29	8	51	53	10	47	32	12	35	38	14	32	24	16	36	55
4	6	51	36	8	55	45	10	51	10	12	39	16	14	36	21	16	41	16
5	6	55	43	8	59	36	10	54	46	12	42	54	14	40	19	16	45	37
6	6	59	50	9	3	26	10	58	23	12	46	33	14	44	18	16	49	59
7	7	3	57	9	7	16	11	2	0	12	50	12	14	48	17	16	54	21
8	7	8	3	9	11	6	11	5	36	12	53	52	14	52	18	16	58	44
9	7	12	9	9	14	55	11	9	12	12	57	32	14	56	19	17	3	7
10	7	16	14	9	18	43	11	12	48	13	1	13	15	0	21	17	7	31
11	7	20	20	9	22	31	11	16	24	13	4	54	15	4	24	17	11	56
12	7	24	24	9	26	18	11	20	0	13	8	35	15	8	28	17	16	20
13	7	28	28	9	30	4	11	23	36	13	12	17	15	12	33	17	20	45
14	7	32	32	9	33	51	11	27	11	13	16	0	15	16	38	17	25	11
15	7	36	36	9	37	36	11	30	47	13	19	43	15	20	45	17	29	36
16	7	40	38	9	41	21	11	34	22	13	23	27	15	24	52	17	34	2
17	7	44	41	9	45	6	11	37	58	13	27	11	15	29	0	17	38	28
18	7	48	43	9	48	50	11	41	33	13	30	56	15	33	9	17	42	55
19	7	52	44	9	52	33	11	45	9	13	34	41	15	37	19	17	47	21
20	7	56	45	9	56	16	11	48	44	13	38	27	15	41	30	17	51	48
21	8	0	45	9	59	59	11	52	20	13	42	14	15	45	41	17	56	14
22	8	4	45	10	3	41	11	55	56	13	46	1	15	49	53	18	0	41
23	8	8	44	10	7	22	11	59	31	13	49	49	15	54	6	18	5	7
24	8	12	42	10	11	3	12	3	7	13	53	38	15	58	20	18	9	34
25	8	16	40	10	14	44	12	6	43	13	57	27	16	2	34	18	14	1
26	8	20	37	10	18	24	12	10	19	14	1	17	16	6	49	18	18	27
27	8	24	34	10	22	4	12	13	55	14	5	8	16	11	5	18	22	53
28	8	28	30	10	25	43	12	17	32	14	8	59	16	15	22	18	27	19
29	8	32	25	10	29	22	12	21	8	14	12	51	16	19	39	18	31	45
30	8	36	20	10	33	1	12	24	45	14	16	44	16	23	57	18	36	11
31	8	40	14	10	36	39				14	20	38				18	40	37

Add 7·3ˢ for every period of four years (see Table XX.) after those for which ⊙'s Right Ascension is given in Table XXI. to find his Right Ascension on the corresponding Day in subsequent Years.

⊙'s Right Ascension when on the Meridian of Greenwich, for every Day in the Year 1823.

Days.	January.			February.			March.			April.			May.			June.		
	h	m	s	h	m	s	h	m	s	h	m	s	h	m	s	h	m	s
1	18	45	2	20	57	28	22	46	42	0	40	17	2	31	24	4	33	57
2	18	49	27	21	1	33	22	50	26	0	43	55	2	35	13	4	38	3
3	18	53	51	21	5	36	22	54	10	0	47	34	2	39	2	4	42	9
4	18	58	16	21	9	39	22	57	54	0	51	12	2	42	52	4	46	15
5	19	2	40	21	13	41	23	1	37	0	54	51	2	46	43	4	50	22
6	19	7	3	21	17	42	23	5	20	0	58	30	2	50	34	4	54	29
7	19	11	26	21	21	42	23	9	2	1	2	9	2	54	26	4	58	36
8	19	15	49	21	25	42	23	12	44	1	5	48	2	58	18	5	2	44
9	19	20	11	21	29	41	23	16	25	1	9	27	3	2	11	5	6	52
10	19	24	32	21	33	39	23	20	6	1	13	7	3	6	4	5	11	0
11	19	28	53	21	37	36	23	23	47	1	16	47	3	9	58	5	15	8
12	19	33	14	21	41	32	23	27	28	1	20	28	3	13	53	5	19	17
13	19	37	34	21	45	28	23	31	8	1	24	8	3	17	48	5	23	26
14	19	41	53	21	49	23	23	34	48	1	27	49	3	21	44	5	27	35
15	19	46	11	21	53	17	23	38	27	1	31	30	3	25	40	5	31	44
16	19	50	29	21	57	10	23	42	7	1	35	12	3	29	37	5	35	54
17	19	54	46	22	1	3	23	45	46	1	38	54	3	33	34	5	40	3
18	19	59	2	22	4	55	23	49	25	1	42	36	3	37	32	5	44	12
19	20	3	18	22	8	46	23	53	3	1	46	19	3	41	30	5	48	22
20	20	7	33	22	12	37	23	56	42	1	50	2	3	45	29	5	52	31
21	20	11	47	22	16	26	0	0	20	1	53	45	3	49	29	5	56	41
22	20	16	0	22	20	15	0	3	58	1	57	29	3	53	29	6	0	50
23	20	20	12	22	24	4	0	7	36	2	1	13	3	57	29	6	5	0
24	20	24	24	22	27	52	0	11	14	2	4	58	4	1	31	6	9	9
25	20	28	35	22	31	39	0	14	52	2	8	43	4	5	32	6	13	18
26	20	32	45	22	35	25	0	18	30	2	12	28	4	9	34	6	17	28
27	20	36	54	22	39	12	0	22	8	2	16	15	4	13	37	6	21	37
28	20	41	3	22	42	57	0	25	45	2	20	1	4	17	40	6	25	46
29	20	45	10				0	29	23	2	23	48	4	21	44	6	29	55
30	20	49	17				0	33	1	2	27	36	4	25	48	6	34	3
31	20	53	23				0	36	39				4	29	52			

Days.	July.			August.			September.			October.			November.			December.		
	h	m	s	h	m	s	h	m	s	h	m	s	h	m	s	h	m	s
1	6	38	12	8	43	11	10	39	24	12	27	30	14	23	36	16	27	13
2	6	42	20	8	47	4	10	43	2	12	31	7	14	27	31	16	31	32
3	6	46	28	8	50	57	10	46	40	12	34	45	14	31	27	16	35	52
4	6	50	36	8	54	49	10	50	17	12	38	23	14	35	24	16	40	13
5	6	54	43	8	58	40	10	53	54	12	42	2	14	39	22	16	44	34
6	6	58	51	9	2	31	10	57	31	12	45	40	14	43	20	16	48	56
7	7	2	58	9	6	21	11	1	8	12	49	20	14	47	20	16	53	18
8	7	7	4	9	10	11	11	4	44	12	52	59	14	51	20	16	57	41
9	7	11	10	9	14	0	11	8	21	12	56	39	14	55	21	17	2	4
10	7	15	16	9	17	49	11	11	57	13	0	20	14	59	23	17	6	28
11	7	19	21	9	21	37	11	15	33	13	4	1	15	3	26	17	10	52
12	7	23	26	9	25	24	11	19	8	13	7	42	15	7	29	17	15	17
13	7	27	30	9	29	11	11	22	44	13	11	24	15	11	34	17	19	41
14	7	31	34	9	32	57	11	26	20	13	15	6	15	15	39	17	24	6
15	7	35	38	9	36	42	11	29	55	13	18	49	15	19	45	17	28	32
16	7	39	41	9	40	27	11	33	30	13	22	32	15	23	52	17	32	58
17	7	43	43	9	44	12	11	37	6	13	26	16	15	28	0	17	37	23
18	7	47	45	9	47	56	11	40	41	13	30	1	15	32	8	17	41	49
19	7	51	46	9	51	39	11	44	16	13	33	46	15	36	17	17	46	16
20	7	55	47	9	55	22	11	47	52	13	37	32	15	40	28	17	50	42
21	7	59	47	9	59	5	11	51	27	13	41	18	15	44	39	17	55	9
22	8	3	46	10	2	47	11	55	3	13	45	5	15	48	51	17	59	35
23	8	7	46	10	6	28	11	58	38	13	48	53	15	53	3	18	4	2
24	8	11	44	10	10	9	12	2	14	13	52	41	15	57	17	18	8	29
25	8	15	42	10	13	50	12	5	50	13	56	30	16	1	31	18	12	55
26	8	19	39	10	17	30	12	9	26	14	0	20	16	5	46	18	17	22
27	8	23	36	10	21	10	12	13	2	14	4	11	16	10	2	18	21	48
28	8	27	32	10	24	50	12	16	39	14	8	2	16	14	19	18	26	15
29	8	31	28	10	28	29	12	20	15	14	11	54	16	18	36	18	30	41
30	8	35	23	10	32	8	12	23	52	14	15	47	16	22	54	18	35	7
31	8	39	17	10	35	46				14	19	41				18	39	33

Add 7·3ˢ for every period of four years (see Table XX.) after those for which ⊙'s Right Ascension is given in Table XXI. to find his Right Ascension on the corresponding Day in subsequent Years.

TABLE XXI.

⊙'s Right Ascension when on the Meridian of Greenwich, for every Day in the Year 1824.

Days.	January.	February.	March.	April.	May.	June.
	h m s	h m s	h m s	h m s	h m s	h m s
1	18 43 58	20 56 30	22 49 34	0 43 5	2 34 20	4 37 5
2	18 48 24	21 0 35	22 53 18	0 46 43	2 38 9	4 41 11
3	18 52 48	21 4 39	22 57 2	0 50 22	2 41 59	4 45 17
4	18 57 13	21 8 42	23 0 45	0 54 0	2 45 49	4 49 24
5	19 1 37	21 12 44	23 4 28	0 57 39	2 49 40	4 53 31
6	19 6 1	21 16 46	23 8 11	1 1 18	2 53 32	4 57 38
7	19 10 24	21 20 46	23 11 52	1 4 57	2 57 24	5 1 45
8	19 14 47	21 24 46	23 15 34	1 8 37	3 1 16	5 5 53
9	19 19 9	21 28 45	23 19 15	1 12 16	3 5 9	5 10 1
10	19 23 30	21 32 43	23 22 56	1 15 56	3 9 3	5 14 9
11	19 27 51	21 36 40	23 26 36	1 19 36	3 12 57	5 18 17
12	19 32 12	21 40 37	23 30 16	1 23 16	3 16 52	5 22 26
13	19 36 31	21 44 32	23 33 56	1 26 57	3 20 48	5 26 35
14	19 40 50	21 48 27	23 37 36	1 30 38	3 24 43	5 30 44
15	19 45 9	21 52 21	23 41 15	1 34 19	3 28 40	5 34 53
16	19 49 27	21 56 15	23 44 54	1 38 1	3 32 37	5 39 2
17	19 53 44	22 0 7	23 48 33	1 41 43	3 36 35	5 43 11
18	19 58 0	22 3 59	23 52 11	1 45 25	3 40 33	5 47 21
19	20 2 16	22 7 51	23 55 50	1 49 8	3 44 32	5 51 30
20	20 6 31	22 11 41	23 59 28	1 52 52	3 48 31	5 55 40
21	20 10 45	22 15 31	0 3 6	1 56 35	3 52 31	5 59 50
22	20 14 59	22 19 21	0 6 44	2 0 20	3 56 32	6 3 59
23	20 19 11	22 23 9	0 10 22	2 4 4	4 0 33	6 8 9
24	20 23 23	22 26 57	0 14 0	2 7 49	4 4 35	6 12 18
25	20 27 34	22 30 45	0 17 38	2 11 35	4 8 37	6 16 28
26	20 31 45	22 34 32	0 21 16	2 15 21	4 12 39	6 20 37
27	20 35 55	22 38 18	0 24 54	2 19 8	4 16 43	6 24 46
28	20 40 3	22 42 4	0 28 32	2 22 55	4 20 46	6 28 55
29	20 44 11	22 45 49	0 32 10	2 26 43	4 24 50	6 33 4
30	20 48 19		0 35 48	2 30 31	4 28 55	6 37 13
31	20 52 25		0 39 27		4 33 0	

Days.	July.	August.	September.	October.	November.	December.
	h m s	h m s	h m s	h m s	h m s	h m s
1	6 41 21	8 46 8	10 42 10	12 30 14	14 26 34	16 30 29
2	6 45 29	8 50 1	10 45 47	12 33 52	14 30 30	16 34 49
3	6 49 37	8 53 53	10 49 25	12 37 30	14 34 26	16 39 9
4	6 53 45	8 57 44	10 53 2	12 41 8	14 38 24	16 43 30
5	6 57 52	9 1 35	10 56 38	12 44 47	14 42 22	16 47 52
6	7 1 58	9 5 25	11 0 15	12 48 26	14 46 21	16 52 14
7	7 6 5	9 9 15	11 3 51	12 52 5	14 50 21	16 56 36
8	7 10 11	9 13 4	11 7 27	12 55 45	14 54 22	17 0 59
9	7 14 16	9 16 53	11 11 3	12 59 25	14 58 23	17 5 23
10	7 18 22	9 20 40	11 14 39	13 3 6	15 2 26	17 9 47
11	7 22 26	9 24 28	11 18 15	13 6 47	15 6 29	17 14 11
12	7 26 31	9 28 14	11 21 50	13 10 29	15 10 33	17 18 36
13	7 30 34	9 32 1	11 25 26	13 14 11	15 14 38	17 23 1
14	7 34 38	9 35 46	11 29 1	13 17 54	15 18 44	17 27 26
15	7 38 41	9 39 32	11 32 37	13 21 37	15 22 51	17 31 52
16	7 42 43	9 43 16	11 36 12	13 25 21	15 26 58	17 36 18
17	7 46 45	9 47 0	11 39 48	13 29 5	15 31 7	17 40 44
18	7 50 47	9 50 44	11 43 23	13 32 50	15 35 16	17 45 11
19	7 54 47	9 54 27	11 46 59	13 36 36	15 39 27	17 49 37
20	7 58 48	9 58 10	11 50 34	13 40 23	15 43 38	17 54 4
21	8 2 48	10 1 52	11 54 10	13 44 10	15 47 50	17 58 31
22	8 6 47	10 5 34	11 57 46	13 47 57	15 52 2	18 2 58
23	8 10 46	10 9 15	12 1 21	13 51 46	15 56 16	18 7 24
24	8 14 44	10 12 56	12 4 57	13 55 35	16 0 30	18 11 51
25	8 18 42	10 16 37	12 8 34	13 59 25	16 4 45	18 16 18
26	8 22 39	10 20 17	12 12 10	14 3 15	16 9 1	18 20 44
27	8 26 35	10 23 57	12 15 46	14 7 6	16 13 17	18 25 11
28	8 30 31	10 27 36	12 19 23	14 10 58	16 17 34	18 29 37
29	8 34 26	10 31 15	12 23 0	14 14 51	16 21 52	18 34 3
30	8 38 21	10 34 53	12 26 37	14 18 45	16 26 10	18 38 29
31	8 42 15	10 38 32		14 22 39		18 42 54

Add $7{\cdot}3^s$ for every period of four years (see Table XX.) after those for which ⊙'s Right Ascension is given in Table XXI. to find his Right Ascension on the corresponding Day in subsequent Years.

TABLE XXI.

⊙'s Right Ascension when on the Meridian of Greenwich, for every Day in the Year 1825.

Days.	January.	February.	March.	April.	May.	June.
	h m s	h m s	h m s	h m s	h m s	h m s
1	18 47 19	20 59 36	22 48 40	0 42 12	2 33 24	4 36 5
2	18 51 44	21 3 40	22 52 24	0 45 50	2 37 13	4 40 10
3	18 56 8	21 7 43	22 56 8	0 49 28	2 41 2	4 44 16
4	19 0 32	21 11 45	22 59 51	0 53 7	2 44 52	4 48 22
5	19 4 56	21 15 46	23 3 34	0 56 45	2 48 43	4 52 29
6	19 9 19	21 19 47	23 7 16	1 0 24	2 52 34	4 56 36
7	19 13 42	21 23 47	23 10 58	1 4 3	2 56 26	5 0 43
8	19 18 4	21 27 46	23 14 39	1 7 42	3 0 19	5 4 51
9	19 22 26	21 31 44	23 18 20	1 11 22	3 4 12	5 8 59
10	19 26 47	21 35 42	23 22 1	1 15 2	3 8 5	5 13 7
11	19 31 7	21 39 38	23 25 42	1 18 42	3 11 59	5 17 16
12	19 35 27	21 43 34	23 29 22	1 22 22	3 15 54	5 21 24
13	19 39 47	21 47 30	23 33 2	1 26 3	3 19 49	5 25 33
14	19 44 5	21 51 24	23 36 42	1 29 44	3 23 45	5 29 43
15	19 48 24	21 55 18	23 40 21	1 33 25	3 27 42	5 33 52
16	19 52 41	21 59 11	23 44 0	1 37 7	3 31 39	5 38 1
17	19 56 58	22 3 3	23 47 39	1 40 49	3 35 37	5 42 11
18	20 1 14	22 6 55	23 51 18	1 44 32	3 39 35	5 46 20
19	20 5 29	22 10 46	23 54 57	1 48 15	3 43 34	5 50 30
20	20 9 44	22 14 36	23 58 35	1 51 58	3 47 33	5 54 40
21	20 13 58	22 18 26	0 2 14	1 55 42	3 51 33	5 58 49
22	20 18 11	22 22 15	0 5 52	1 59 26	3 55 34	6 2 59
23	20 22 23	22 26 3	0 9 30	2 3 10	3 59 35	6 7 8
24	20 26 34	22 29 50	0 13 8	2 6 55	4 3 36	6 11 18
25	20 30 45	22 33 37	0 16 46	2 10 41	4 7 38	6 15 27
26	20 34 55	22 37 24	0 20 24	2 14 27	4 11 41	6 19 36
27	20 39 4	22 41 10	0 24 2	2 18 13	4 15 43	6 23 45
28	20 43 12	22 44 55	0 27 40	2 22 0	4 19 47	6 27 54
29	20 47 19		0 31 18	2 25 48	4 23 51	6 32 3
30	20 51 25		0 34 56	2 29 36	4 27 55	6 36 11
31	20 55 31		0 38 34		4 32 0	

Days.	July.	August.	September.	October.	November.	December.
	h m s	h m s	h m s	h m s	h m s	h m s
1	6 40 20	8 45 10	10 41 16	12 29 21	14 25 37	16 29 27
2	6 44 28	8 49 3	10 44 54	12 32 59	14 29 33	16 33 46
3	6 48 35	8 52 55	10 48 31	12 36 37	14 33 29	16 38 7
4	6 52 43	8 56 47	10 52 8	12 40 15	14 37 26	16 42 27
5	6 56 50	9 0 38	10 55 45	12 43 54	14 41 24	16 46 49
6	7 0 57	9 4 28	10 59 22	12 47 33	14 45 23	16 51 11
7	7 5 3	9 8 18	11 2 58	12 51 12	14 49 23	16 55 34
8	7 9 9	9 12 7	11 6 35	12 54 52	14 53 24	16 59 57
9	7 13 15	9 15 56	11 10 11	12 58 32	14 57 26	17 4 20
10	7 17 21	9 19 44	11 13 47	13 2 13	15 1 28	17 8 44
11	7 21 26	9 23 32	11 17 23	13 5 54	15 5 31	17 13 9
12	7 25 30	9 27 19	11 20 59	13 9 36	15 9 36	17 17 33
13	7 29 34	9 31 6	11 24 34	13 13 18	15 13 40	17 21 58
14	7 33 38	9 34 52	11 28 10	13 17 1	15 17 46	17 26 24
15	7 37 41	9 38 37	11 31 45	13 20 44	15 21 53	17 30 50
16	7 41 44	9 42 22	11 35 21	13 24 28	15 26 0	17 35 15
17	7 45 46	9 46 6	11 38 56	13 28 12	15 30 9	17 39 42
18	7 49 48	9 49 50	11 42 32	13 31 57	15 34 18	17 44 8
19	7 53 49	9 53 34	11 46 7	13 35 43	15 38 28	17 48 34
20	7 57 50	9 57 16	11 49 43	13 39 29	15 42 38	17 53 1
21	8 1 50	10 0 59	11 53 18	13 43 16	15 46 50	17 57 27
22	8 5 49	10 4 41	11 56 54	13 47 3	15 51 2	18 1 54
23	8 9 48	10 8 22	12 0 30	13 50 51	15 55 15	18 6 20
24	8 13 46	10 12 3	12 4 6	13 54 40	15 59 29	18 10 47
25	8 17 44	10 15 43	12 7 42	13 58 30	16 3 44	18 15 13
26	8 21 41	10 19 23	12 11 18	14 2 20	16 7 59	18 19 40
27	8 25 37	10 23 3	12 14 54	14 6 11	16 12 15	18 24 6
28	8 29 33	10 26 42	12 18 30	14 10 2	16 16 32	18 28 32
29	8 33 28	10 30 21	12 22 7	14 13 55	16 20 50	18 32 58
30	8 37 23	10 34 0	12 25 44	14 17 48	16 25 8	18 37 24
31	8 41 17	10 37 38		14 21 42		18 41 49

Add $7^{s}.3^{s}$ four every period of four years (see Table XX.) after those for which ⊙'s Right Ascension is given in Table XXI. to find his Right Ascension on the corresponding Day in subsequent Years.

TABLE XXII.

Equation of Time when ⊙ is on the Meridian of Greenwich, for every Day in the Year 1822.

Days	Jan.		Feb.		Mar.		April.		May.		June.		July		Aug.		Sept.		Oct.		Nov.		Dec.	
	Add		Add		Add		Add		Sub.		Sub.		Add		Add		Sub.		Sub.		Sub.		Sub.	
	m	s	m	s	m	s	m	s	m	s	m	s	m	s	m	s	m	s	m	s	m	s	m	s
1	3	49	13	56	12	42	4	4	3	2	2	38	3	19	6	0	0	3	10	12	16	14	10	49
2	4	18	14	4	12	30	3	45	3	10	2	30	3	30	5	57	0	21	10	31	16	16	10	26
3	4	46	14	10	12	17	3	27	3	17	2	20	3	42	5	52	0	40	10	50	16	16	10	3
4	5	13	14	16	12	4	3	9	3	24	2	11	3	53	5	48	1	0	11	9	16	16	9	39
5	5	40	14	21	11	50	2	51	3	30	2	1	4	3	5	42	1	19	11	27	16	14	9	14
6	6	7	14	26	11	36	2	33	3	35	1	50	4	14	5	36	1	39	11	44	16	12	8	49
7	6	33	14	29	11	22	2	16	3	40	1	40	4	24	5	30	1	59	12	2	16	9	8	23
8	6	59	14	32	11	7	1	58	3	44	1	29	4	33	5	22	2	19	12	19	16	5	7	57
9	7	24	14	34	10	51	1	41	3	48	1	18	4	42	5	15	2	40	12	35	16	1	7	30
10	7	48	14	35	10	36	1	24	3	51	1	6	4	51	5	7	3	0	12	51	15	55	7	3
11	8	12	14	35	10	20	1	8	3	54	0	54	5	0	4	58	3	21	13	6	15	48	6	35
12	8	36	14	34	10	3	0	52	3	56	0	42	5	8	4	48	3	42	13	21	15	41	6	7
13	8	59	14	33	9	47	0	36	3	57	0	30	5	16	4	38	4	2	13	36	15	33	5	39
14	9	21	14	31	9	30	0	20	3	58	0	17	5	23	4	28	4	23	13	50	15	24	5	10
15	9	42	14	29	9	13	0	5	3	58	0	5	5	30	4	17	4	44	14	3	15	14	4	41
							Sub.				Add													
16	10	3	14	25	8	56	0	10	3	58	0	8	5	36	4	6	5	5	14	16	15	3	4	12
17	10	24	14	21	8	38	0	25	3	57	0	21	5	42	3	54	5	26	14	28	14	52	3	42
18	10	43	14	17	8	20	0	39	3	55	0	34	5	47	3	41	5	47	14	40	14	40	3	13
19	11	2	14	11	8	3	0	53	3	53	0	47	5	52	3	28	6	8	14	51	14	26	2	43
20	11	20	14	5	7	45	1	6	3	50	1	0	5	56	3	15	6	29	15	1	14	12	2	13
21	11	38	13	58	7	27	1	19	3	47	1	13	6	0	3	1	6	50	15	11	13	58	1	43
22	11	54	13	51	7	8	1	31	3	43	1	26	6	3	2	46	7	11	15	20	13	42	1	13
23	12	10	13	43	6	50	1	43	3	39	1	39	6	5	2	31	7	32	15	29	13	26	0	43
24	12	25	13	34	6	32	1	55	3	34	1	52	6	7	2	16	7	52	15	37	13	9	0	13
																							Add	
25	12	40	13	25	6	13	2	6	3	29	2	5	6	8	2	0	8	13	15	44	12	51	0	17
26	12	53	13	15	5	55	2	16	3	23	2	18	6	9	1	43	8	33	15	51	12	32	0	47
27	13	6	13	4	5	36	2	27	3	17	2	31	6	9	1	27	8	53	15	57	12	13	1	16
28	13	17	12	53	5	18	2	36	3	10	2	43	6	9	1	10	9	13	16	2	11	53	1	46
29	13	28			4	59	2	45	3	3	2	55	6	7	0	52	9	33	16	6	11	32	2	15
30	13	38			4	41	2	54	2	55	3	7	6	6	0	34	9	53	16	10	11	11	2	44
31	13	48			4	22			2	47			6	3	0	16			16	12			3	13

The Equation of Time from Table XXII. may be reduced to subsequent Years by Part I. of Table XX., by considering the *seconds of arc* in that Table, as *seconds of time* in the *daily difference* of the *Equation of Time*.

TABLE XXII.

Equation of Time when ⊙ is on the Meridian of Greenwich, for every Day in the Year 1823

Days	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	Add	Add	Add	Add	Sub.	Sub.	Add	Add	Add	Sub.	Sub.	Sub.
	m s	m s	m s	m s	m s	m s	m s	m s	m s	m s	m s	m s
1	3 42	13 53	12 43	4 7	3 2	2 42	3 15	6 0	0 2	10 8	16 14	10 55
									Sub.			
2	4 10	14 1	12 31	3 49	3 9	2 33	3 27	5 57	0 17	10 27	16 16	10 32
3	4 38	14 8	12 19	3 30	3 17	2 24	3 38	5 53	0 36	10 46	16 16	10 8
4	5 6	14 14	12 6	3 12	3 23	2 14	3 49	5 49	0 55	11 4	16 16	9 44
5	5 33	14 19	11 52	2 55	3 29	2 4	4 0	5 44	1 14	11 22	16 14	9 20
6	6 0	14 24	11 39	2 37	3 35	1 53	4 11	5 38	1 34	11 40	16 12	8 55
7	6 26	14 28	11 24	2 19	3 39	1 43	4 21	5 32	1 54	11 57	16 9	8 29
8	6 52	14 31	11 10	2 2	3 44	1 31	4 31	5 25	2 14	12 14	16 6	8 3
9	7 18	14 33	10 55	1 45	3 47	1 20	4 41	5 17	2 34	12 30	16 1	7 36
10	7 42	14 35	10 39	1 28	3 51	1 8	4 50	5 9	2 55	12 46	15 56	7 9
11	8 7	14 35	10 23	1 12	3 53	0 57	4 59	5 1	3 15	13 2	15 50	6 42
12	8 31	14 35	10 7	0 56	3 55	0 44	5 7	4 52	3 36	13 17	15 43	6 14
13	8 54	14 34	9 51	0 40	3 57	0 32	5 15	4 42	3 57	13 32	15 35	5 46
14	9 16	14 32	9 34	0 24	3 57	0 20	5 22	4 31	4 18	13 46	15 26	5 17
15	9 38	14 30	9 18	0 9	3 58	0 7	5 29	4 20	4 39	14 0	15 17	4 48
				Sub.		Add						
16	9 59	14 27	9 0	0 6	3 57	0 6	5 35	4 9	5 0	14 13	15 7	4 19
17	10 20	14 23	8 43	0 21	3 57	0 18	5 41	3 57	5 21	14 26	14 55	3 50
18	10 39	14 18	8 25	0 35	3 55	0 31	5 46	3 44	5 42	14 38	14 44	3 21
19	10 58	14 13	8 7	0 49	3 53	0 44	5 51	3 31	6 3	14 49	14 31	2 51
20	11 17	14 7	7 49	1 3	3 51	0 57	5 55	3 18	6 24	15 0	14 17	2 21
21	11 34	14 0	7 31	1 16	3 48	1 10	5 59	3 4	6 46	15 10	14 3	1 52
22	11 51	13 53	7 13	1 28	3 44	1 23	6 2	2 49	7 7	15 19	13 47	1 22
23	12 7	13 45	6 54	1 41	3 40	1 36	6 4	2 34	7 27	15 28	13 31	0 52
24	12 22	13 36	6 36	1 52	3 36	1 49	6 6	2 19	7 48	15 36	13 14	0 21
												Add
25	12 36	13 26	6 17	2 4	3 31	2 1	6 7	2 3	8 9	15 44	12 57	0 9
26	12 49	13 17	5 59	2 15	3 25	2 14	6 8	1 47	8 29	15 50	12 38	0 39
27	13 2	13 6	5 40	2 25	3 19	2 26	6 8	1 30	8 50	15 56	12 19	1 8
28	13 14	12 55	5 21	2 35	3 13	2 39	6 8	1 13	9 10	16 2	11 59	1 38
29	13 25		5 3	2 44	3 6	2 51	6 7	0 56	9 29	16 6	11 38	2 8
30	13 35		4 44	2 53	2 58	3 3	6 5	0 38	9 49	16 10	11 17	2 37
31	13 44		4 25		2 50		6 3	0 20		16 12		3 6

The Equation of Time from Table XXII. may be reduced to subsequent Years by Part I. of Table XX., by considering the *seconds of arc* in that Table as *seconds of time* in the *daily difference* of the *Equation of Time.*

TABLE XXII.

Equation of Time when ⊙ is on the Meridian of Greenwich, for every Day in the Year 1824.

Days	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	Add	Add	Add	Add	Sub.	Sub.	Add	Add	Sub.	Sub.	Sub.	Sub.
	m s	m s	m s	m s	m s	m s	m s	m s	m s	m s	m s	m s
1	3 35	13 52	12 36	3 55	3 5	2 33	3 25	5 58	0 12	10 23	16 15	10 37
2	4 4	14 1	12 24	3 37	3 13	2 24	3 37	5 54	0 31	10 41	16 16	10 14
3	4 32	14 8	12 11	3 19	3 19	2 14	3 48	5 50	0 51	11 0	16 16	9 51
4	5 0	14 14	11 58	3 1	3 25	2 5	3 59	5 45	1 10	11 18	16 15	9 26
5	5 27	14 20	11 44	2 44	3 31	1 54	4 9	5 39	1 30	11 36	16 14	9 2
6	5 54	14 25	11 30	2 26	3 36	1 44	4 19	5 33	1 50	11 54	16 11	8 36
7	6 21	14 29	11 15	2 9	3 41	1 33	4 29	5 26	2 10	12 11	16 8	8 10
8	6 47	14 32	11 0	1 51	3 45	1 22	4 39	5 19	2 30	12 28	16 4	7 44
9	7 13	14 34	10 45	1 34	3 48	1 11	4 48	5 10	2 51	12 44	15 59	7 17
10	7 38	14 36	10 29	1 18	3 51	0 59	4 56	5 2	3 12	13 0	15 53	6 50
11	8 2	14 36	10 13	1 1	3 53	0 47	5 4	4 53	3 32	13 15	15 46	6 22
12	8 26	14 36	9 57	0 45	3 55	0 35	5 12	4 43	3 53	13 30	15 38	5 54
13	8 49	14 35	9 40	0 29	3 56	0 23	5 19	4 32	4 14	13 44	15 30	5 26
14	9 11	14 34	9 23	0 14	3 57	0 10	5 26	4 22	4 35	13 58	15 21	4 57
				Sub.		Add						
15	9 33	14 31	9 6	0 2	3 57	0 2	5 32	4 10	4 56	14 11	15 10	4 28
16	9 54	14 28	8 48	0 16	3 56	0 15	5 38	3 58	5 17	14 24	14 59	3 58
17	10 15	14 24	8 30	0 31	3 55	0 28	5 44	3 46	5 38	14 36	14 47	3 29
18	10 34	14 20	8 13	0 45	3 54	0 40	5 49	3 33	5 59	14 47	14 35	2 59
19	10 54	14 15	7 54	0 59	3 51	0 53	5 53	3 20	6 20	14 58	14 21	2 29
20	11 12	14 9	7 36	1 12	3 48	1 6	5 57	3 6	6 41	15 8	14 6	1 59
21	11 30	14 2	7 18	1 25	3 45	1 19	6 0	2 52	7 2	15 18	13 51	1 29
22	11 46	13 55	7 0	1 37	3 41	1 32	6 3	2 37	7 23	15 26	13 35	0 59
23	12 3	13 47	6 41	1 49	3 36	1 45	6 5	2 22	7 44	15 35	13 18	0 28
												Add
24	12 18	13 39	6 23	2 0	3 31	1 58	6 7	2 6	8 4	15 42	13 1	0 2
25	12 33	13 30	6 4	2 11	3 26	2 11	6 8	1 50	8 24	15 49	12 42	0 32
26	12 46	13 20	5 46	2 21	3 20	2 24	6 8	1 34	8 45	15 55	12 23	1 2
27	12 59	13 10	5 27	2 31	3 13	2 37	6 8	1 17	9 5	16 0	12 3	1 31
28	13 12	12 59	5 9	2 40	3 6	2 49	6 7	1 0	9 24	16 5	11 43	2 1
29	13 23	12 48	4 50	2 49	2 58	3 1	6 6	0 42	9 44	16 8	11 22	2 30
30	13 34		4 32	2 58	2 50	3 13	6 4	0 24	10 3	16 12	11 0	2 59
31	13 44		4 13		2 42		6 1	0 6		16 14		3 28

The Equation of Time from Table XXII. may be reduced to subsequent Years by Part I. of Table XX., by considering the *seconds* of *arc* in that Table as *seconds of time* in the *daily difference* of the *Equation of Time*.

TABLE XXII.

Equation of Time when ⊙ is on the Meridian of Greenwich, for every Day in the Year 1825

Days	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	Add	Add	Add	Add	Sub.	Sub.	Add	Add	Sub.	Sub.	Sub.	Sub.
	m s	m s	m s	m s	m s	m s	m s	m s	m s	m s	m s	m s
1	3 57	13 58	12 39	3 59	3 4	2 37	3 21	5 58	0 9	10 18	16 15	10 43
2	4 25	14 6	12 27	3 41	3 12	2 28	3 32	5 54	0 28	10 37	16 16	10 20
3	4 53	14 12	12 14	3 23	3 19	2 18	3 43	5 50	0 47	10 56	16 16	9 56
4	5 20	14 18	12 1	3 5	3 25	2 9	3 54	5 45	1 6	11 14	16 15	9 32
5	5 47	14 23	11 47	2 47	3 31	1 59	4 5	5 39	1 26	11 32	16 14	9 7
6	6 13	14 27	11 33	2 29	3 36	1 48	4 15	5 33	1 46	11 50	16 11	8 42
7	6 39	14 30	11 18	2 12	3 41	1 37	4 25	5 26	2 6	12 7	16 8	8 16
8	7 5	14 32	11 3	1 54	3 45	1 26	4 34	5 19	2 26	12 23	16 4	7 49
9	7 30	14 34	10 48	1 37	3 49	1 15	4 44	5 11	2 46	12 39	15 59	7 22
10	7 55	14 35	10 32	1 21	3 52	1 3	4 52	5 3	3 7	12 55	15 53	6 55
11	8 18	14 35	10 16	1 4	3 54	0 51	5 1	4 54	3 27	13 11	15 46	6 27
12	8 42	14 35	10 0	0 48	3 56	0 39	5 9	4 45	3 48	13 25	15 39	5 59
13	9 5	14 33	9 43	0 32	3 57	0 27	5 17	4 35	4 9	13 40	15 30	5 31
14	9 27	14 31	9 26	0 17	3 58	0 14	5 24	4 24	4 29	13 53	15 21	5 2
15	9 48	14 29	9 9	0 2	3 58	0 2	5 30	4 13	4 50	14 7	15 11	4 33
				Sub.		Add						
16	10 9	14 25	8 52	0 13	3 57	0 11	5 37	4 1	5 11	14 19	15 0	4 3
17	10 29	14 21	8 35	0 28	3 56	0 24	5 42	3 49	5 32	14 31	14 48	3 34
18	10 49	14 16	8 17	0 41	3 54	0 37	5 47	3 37	5 53	14 43	14 36	3 4
19	11 7	14 10	7 59	0 55	3 52	0 50	5 52	3 23	6 14	14 54	14 23	2 35
20	11 25	14 4	7 41	1 8	3 49	1 3	5 56	3 10	6 35	15 4	14 8	2 5
21	11 43	13 57	7 23	1 21	3 46	1 16	5 59	2 56	6 56	15 14	13 54	1 35
22	11 59	13 50	7 5	1 33	3 42	1 29	6 2	2 41	7 17	15 23	13 38	1 5
23	12 15	13 41	6 46	1 45	3 37	1 42	6 4	2 26	7 38	15 32	13 21	0 35
24	12 30	13 32	6 28	1 57	3 32	1 55	6 6	2 10	7 59	15 39	13 4	0 5
												Add
25	12 44	13 23	6 9	2 8	3 27	2 8	6 7	1 54	8 19	15 46	12 46	0 25
26	12 57	13 13	5 51	2 18	3 21	2 20	6 8	1 38	8 40	15 53	12 27	0 55
27	13 9	13 2	5 32	2 29	3 15	2 33	6 7	1 21	9 0	15 58	12 8	1 24
28	13 21	12 51	5 14	2 38	3 8	2 45	6 7	1 4	9 20	16 3	11 48	1 54
29	13 31		4 55	2 47	3 1	2 57	6 5	0 46	9 40	16 7	11 27	2 23
30	13 41		4 36	2 56	2 53	3 9	6 3	0 28	9 59	16 11	11 5	2 52
31	13 50		4 18		2 45		6 1	0 10		16 13		3 21

The Equation of Time from Table XXII. may be reduced to subsequent Years by Part I. of Table XX., by considering the *seconds* of *arc* in that Table as *seconds of time* in the *daily difference* of the *Equation of Time.*

TABLE XXIII.

Mean Right Ascension and Declination of sixty of the principal fixed Stars, January 1, 1820, with their Annual Variations.

Characters	Constellations.	Pr. Names.	Right Ascension.	Annual Var.	Declination	Annual Var.
			h m s	Sec.	° ′ ″	″
γ	Pegasi	Algenib	0 3 58	+ 3·07	14 11 0 N	+20·09
α	Phœnicis		0 17 22	+ 2·97	43 17 16 S	−19·95
α	Cassiopeia	Schedar	0 30 21	+ 3·32	55 32 55 N	+19·89
β	Cetus	Deneb Kaitos	0 34 33	+ 3·01	18 58 33 S	−19·90
α	Ursa Minor	Pole Star	0 57 2	+14·74	88 20 54 N	+19·45
β	Andromeda	Mirach	0 59 41	+ 3·33	34 39 51 N	+19·33
α	Eridanus	Achernar	1 31 0	+ 2·24	58 9 13 S	−18·51
α	Aries	ARIETES	1 57 3	+ 3·35	22 36 24 N	+17·40
α	Cetus	Menkar	2 52 53	+ 3·12	3 22 40 N	+14·59
β	Perseus	Algol	2 56 29	+ 3·81	40 14 18 N	+14·35
α	Perseus		3 11 32	+ 4·20	49 12 41 N	+13·46
α	Taurus	ALDEBARAN	4 25 36	+ 3·43	16 8 19 N	+ 7·92
α	Auriga	Capella	5 3 24	+ 4·42	45 48 19 N	+ 4·57
β	Orion	Rigel	5 5 53	+ 2·88	8 25 2 S	− 4·74
β	Taurus		5 14 55	+ 3·78	28 26 42 N	+ 3·80
γ	Orion	Bellatrix	5 15 29	+ 3·20	6 10 39 N	+ 3·90
δ	Orion		5 22 49	+ 3·05	0 26 26 S	− 3·37
α	Columba		5 33 6	+ 2·17	34 10 35 S	− 2·20
α	Orion	Betilguese	5 45 26	+ 3·25	7 21 52 N	+ 1·36
α	Argo	Canopus	6 19 55	+ 1·33	52 35 59 S	+ 1·68
α	Canis Major	Sirius	6 37 13	+ 2·65	16 28 35 S	+ 4·41
α	Gemini	Castor	7 23 6	+ 3·85	32 16 22 N	− 7·12
α	Canis Minor	Procyon	7 29 52	+ 3·14	5 40 42 N	− 8·63
β	Gemini	POLLUX	7 34 17	+ 3·69	28 27 7 N	− 8·02
ζ	Argo Navis		7 57 15	+ 2·11	39 30 3 S	+ 9·75
γ	Argo Navis		8 4 0	+ 1·85	46 48 30 S	+10·26
δ	Argo Navis		8 39 45	+ 1·65	54 2 57 S	+12·83
α	Hydra	Alphard	9 18 45	+ 2·95	7 52 58 S	+15·19
α	Leo	REGULUS	9 58 47	+ 3·21	12 50 36 N	−17·23
β	Ursa Major		10 50 54	+ 3·68	57 20 42 N	−19·10
α	Ursa Major	Dubhe	10 52 32	+ 3·82	62 43 14 N	−19·26
β	Leo	Deneb	11 39 52	+ 3·06	15 34 42 N	−20·04
α	Crux		12 16 44	+ 3·25	62 6 5 S	+20·00
γ	Crux		12 21 14	+ 3·25	56 6 2 S	+19·97
β	Crux		12 37 17	+ 3·43	58 42 11 S	+19·74
α	Virgo	SPICA	13 15 44	+ 3·15	10 13 4 S	+18·94
η	Ursa Major	Benetnasch	13 40 26	+ 2·38	50 12 55 N	−18·15
β	Centaur		13 51 13	+ 4·12	59 29 48 S	+17·80
α	Draconis		13 59 31	+ 1·63	65 14 21 N	−17·41
α	Bootes	Arcturus	14 7 27	+ 2·73	20 7 28 N	−18·97
α	Centaur.		14 27 59	+ 4·47	60 5 59 S	+16·11
α	Libra	Zubenesch	14 40 56	+ 3·29	15 14 26 S	+15·26
β	Libra	Zubenelg	15 7 20	+ 3·22	8 42 38 S	+13·67
α	Corona Borealis	Alphacca	15 27 4	+ 2·54	27 19 37 N	−12·45
α	Serpens		15 35 25	+ 2·94	6 59 58 N	−11·72
α	Scorpio	ANTARES	16 18 23	+ 3·65	26 1 18 S	+ 8·59
α	Hercules	Ras Algethi	17 6 27	+ 2·73	14 36 14 N	− 4·57
α	Ophiucus	Ras Alhagus	17 26 35	+ 2·77	12 41 59 N	− 3·08
γ	Draco	Rastaban	17 52 26	+ 1·39	51 30 51 N	− 0·67
α	Lyra	Vega	18 30 51	+ 2·03	38 37 20 N	+ 3·02
β	Cygnus		19 23 28	+ 2·41	27 35 16 N	+ 7·00
α	Aquila	ALTAIR	19 42 0	+ 2·93	8 24 4 N	+ 9·06
α	Pavo		20 11 20	+ 4·81	57 18 1 S	−10·72
α	Cygnus	Deneb	20 35 18	+ 2·04	44 38 30 N	+12·63
α	Cepheus	Alderamin	21 14 17	+ 1·42	61 49 32 N	+15·07
α	Aquarius		21 56 32	+ 3·09	1 11 22 S	−17·27
α	Crux		21 56 50	+ 3·84	47 49 25 S	−17·14
α	Pisc. Austr.	FOMALHAUT	22 47 41	+ 3·34	30 34 24 S	−18·86
β	Pegasus	Scheat	22 55 4	+ 2·96	27 6 34 N	+19·50
α	Pegasus	MARCAB	22 55 48	+ 2·98	14 14 20 N	+19·32
α	Andromeda	Alpheratz	23 59 6	+ 3·08	28 5 48 N	+19·05

TABLES XXIV. AND XXV.

CORRECTION

OF

☽'s APPARENT ALTITUDE,

AND AUXILIARY ARCS USED IN CLEARING THE LUNAR DISTANCE.

AS THESE TABLES HAVE THE SAME GENERAL ARGUMENTS, AND ARE USED JOINTLY IN THE LUNAR PROBLEM, THEY ARE SO PRINTED THAT THE DEGREES, &c. WANTED IN EACH TABLE MAY APPEAR AT ONE OPENING OF THE BOOK; TABLE XXIV. BEING ON THE LEFT HAND PAGE, AND TABLE XXV. ON THE RIGHT.

TABLE XXIV.

Correction of ☽'s Apparent Altitude.

Parts for Min. of Alt. *Add*		☽'s App. Alt.	☽'s Horizontal Parallax.								Parts for Seconds of Parallax. *Add*			
			54′	55′	56′	57′	58′	59′	60′	61′	Parts	Parallax.		Parts
		° ′	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″				
		2 0	35 23	36 23	37 23	38 23	39 23	40 23	41 23	42 23	//	//	//	//
		4	42	42	42	42	42	42	42	42				
		8	36 0	37 0	38 0	39 0	40 0	41 0	42 0	43 0				
		12	19	19	19	19	19	19	19	19				
		16	36	36	36	36	36	36	36	36				
Alt.	Parts	20	53	53	53	53	53	53	53	53				
°	′	24	37 9	38 9	39 9	40 9	41 9	42 9	43 9	44 9				
0	0	28	25	25	25	25	25	25	25	25				
1	4	32	42	41	41	41	41	41	41	41				
2	8	36	57	57	56	56	56	56	56	56				
3	12	40	38 12	39 12	40 11	41 11	42 11	43 11	44 11	45 11				
		44	26	26	25	25	25	25	25	25			1	1
		48	40	40	39	39	39	39	39	39			2	2
		52	54	54	54	54	54	54	54	54	10	10	3	3
		56	39 7	40 7	41 7	42 7	43 7	44 7	45 7	46 7	20	20	4	4
		3 0	39 21	40 20	41 20	42 20	43 20	44 20	45 20	46 20	30	30	5	5
		4	34	33	33	33	33	33	33	33	40	40	6	6
		8	46	45	45	45	45	45	45	45	50	50	7	7
		12	58	58	58	58	57	57	57	57			8	8
		16	40 10	41 10	42 10	43 10	44 9	45 9	46 9	47 9			9	9
0	0	20	21	21	21	21	21	21	21	20				
1	3	24	32	32	32	32	32	32	32	31				
2	5	28	43	43	43	43	43	43	43	42				
3	8	32	54	54	54	53	53	53	53	53				
		36	41 5	42 5	43 5	44 4	45 4	46 4	47 4	48 4				
		40	15	14	14	14	14	14	14	14				
		44	25	24	24	24	24	24	24	24				
		48	35	34	34	34	34	34	34	34				
		52	44	44	44	44	43	43	43	43				
		56	53	53	53	53	52	52	52	52				
		4 0	42 2	43 2	44 2	45 2	46 1	47 1	48 1	49 1				
		4	11	11	11	10	10	10	10	10				
		8	19	19	19	18	18	18	18	18				
		12	28	27	27	27	27	27	27	26				
		16	36	35	35	35	35	35	35	34				
0	0	20	44	44	44	43	43	43	43	43				
1	2	24	52	52	52	51	51	51	51	51				
2	4	28	59	59	59	59	58	58	58	59				
3	5	32	43 7	44 7	45 7	46 7	47 6	48 6	49 6	50 6				
		36	14	14	14	14	13	13	13	13				
		40	21	21	21	21	21	20	20	20				
		44	28	28	28	28	28	27	27	27			1	1
		48	35	35	35	35	35	34	34	34			2	2
		52	42	41	41	41	41	40	40	40	10	10	3	3
		56	49	48	48	48	48	47	47	47	20	20	4	4
		5 0	43 55	44 54	45 54	46 54	47 54	48 54	49 53	50 53	30	30	5	5
		4	44 1	45 0	46 0	47 0	48 0	49 0	59	59	40	40	6	6
		8	7	6	6	6	6	6	50 5	51 5	50	50	7	7
		12	13	13	13	12	12	12	12	11			8	8
		16	19	19	19	18	18	18	18	17			9	9
0	0	20	25	24	24	24	24	23	23	23				
1	1	24	30	29	29	29	29	28	28	28				
2	3	28	36	35	35	35	35	34	34	34				
3	5	32	41	41	41	41	40	40	40	39				
		36	46	46	46	46	45	45	45	44				
		40	51	51	51	51	50	50	50	49				
		44	56	56	56	56	55	55	55	54				
		48	45 1	46 1	47 1	48 1	49 0	50 0	51 0	59				
		52	6	5	5	5	5	4	4	52 4				
		56	11	10	10	10	10	9	9	9				

TABLE XXV.

Auxiliary Arcs used in clearing the Lunar Distance.

Parts for Min. of ☽'s Alt. *Add*	☾'s App. Alt.	☽'s Horizontal Parallax. 54′	55′	56′	57′	58′	59′	60′	61′	Parts for Seconds of Parallax. *Add* Parts	Paral-lax.	Parts	Correction for Alt. of ☉ or ✳ *Add* ☉
	° ′	60° 0′ 16″	60° 0′ 18″	60° 0′ 19″	60° 0′ 21″	60° 0′ 22″	60° 0′ 24″	60° 0′ 26″	60° 0′ 27″	″	″	″	
	2 0												° ″
Alt. Parts	4	18	20	21	23	24	26	28	29				3 8
′ ″	8	20	22	23	25	27	29	31	32				4 5
	12	22	24	25	27	29	31	33	34				5 4
	16	24	26	28	30	31	33	35	37				6 3
	20	26	28	30	32	33	35	37	39				7 2
0 0	24	28	30	32	34	35	37	39	41				8 2
1 1	28	30	32	34	36	38	40	42	44				9 2
2 1	32	32	34	36	38	40	42	44	46				10 2
3 2	36	34	36	38	40	42	44	46	48				20 2
	40	36	38	40	42	44	46	48	50				30 3
	44	38	40	42	44	46	48	50	52				40 3
	48	40	42	45	47	49	51	53	55				50 4
	52	42	44	47	49	51	53	55	57			1 0	60 4
	56	44	47	49	51	53	55	58	1 0			2 0	70 5
	3 0	0 46	0 49	0 51	0 53	0 55	0 57	1 0	1 2	0	10	3 0	80 5
	4	48	51	53	55	57	59	2	4	1	20	4 0	90 5
	8	50	53	56	58	1 0	1 2	5	7	1	30	5 0	
	12	52	55	58	1 0	2	4	7	9	1	40	6 0	
	16	55	58	1 0	2	4	7	10	12	2	50	7 0	
0 0	20	57	1 0	2	4	6	9	12	14			8 0	✳
1 1	24	59	2	4	6	8	11	14	16			9 0	
2 1	28	1 1	4	7	9	11	14	17	19				
3 2	32	3	6	9	11	13	16	19	21				
	36	5	8	11	13	16	18	21	24				
	40	7	10	13	15	18	20	23	26				
	44	9	12	15	17	20	22	25	28				
	48	12	15	18	20	22	25	28	31				
	52	14	17	20	22	24	27	30	33				
	56	16	19	22	24	27	30	33	36				
	4 0	1 18	1 21	1 24	1 26	1 29	1 32	1 35	1 38				° ″
	4	20	23	26	28	31	34	37	40				3 8
	8	22	25	28	31	34	37	40	43				4 5
	12	24	27	30	33	36	39	42	45				5 4
	16	27	30	33	36	39	42	45	48				6 3
0 0	20	29	32	35	38	41	44	47	50				7 2
1 1	24	31	34	37	40	43	46	49	52				8 2
2 1	28	33	36	39	42	46	49	52	55				9 1
3 2	32	35	38	41	44	48	51	54	57				10 1
	36	37	40	44	47	50	53	57	2 0				20 0
	40	39	42	46	49	52	55	59	2				30 0
	44	41	44	48	51	54	57	2 1	4			1 0	40 0
	48	44	47	50	53	57	2 0	4	7			2 0	50 0
	52	46	49	52	55	59	2	6	9	1	10	3 0	60 0
	56	48	51	55	58	2 2	5	9	12	1	20	4 0	70 0
	5 0	1 50	1 53	1 57	2 0	2 4	2 7	2 11	2 14	2	30	5 0	80 0
	4	52	55	59	2	6	9	13	16	2	40	6 0	90 0
	8	54	58	2 2	5	9	12	16	19	3	50	7 0	
	12	56	2 1	4	7	11	14	18	21			8 0	
	16	59	2	6	10	14	17	21	24			9 1	
0 0	20	2 1	4	8	12	16	19	23	26				
1 1	24	3	6	10	14	18	21	25	29				
2 1	28	5	9	13	17	21	24	28	32				
3 2	32	7	11	15	19	23	26	30	34				
	36	9	13	17	21	25	29	33	37				
	40	11	15	19	23	27	31	35	39				
	44	13	17	21	25	29	33	37	41				
	48	16	20	24	27	31	35	40	44				
	52	18	22	26	29	33	37	42	46				
	56	20	24	28	32	36	40	45	49				

TABLE XXIV.

Correction of ☽'s Apparent Altitude.

Parts for Min. of Alt. *Add*	☽'s App. Alt.	☽'s Horizontal Parallax. 54′	55′	56′	57′	58′	59′	60′	61′	Parts for Seconds of Parallax. *Add* Parts	Parallax.	Parts
	° ′	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″			
	6 0	45 16	46 15	47 15	48 15	49 14	50 14	51 14	52 13			
	4	20	19	19	19	18	18	18	17			
	8	25	24	24	24	23	23	23	22			
	12	29	28	28	28	27	27	27	26			
	16	33	33	33	32	32	31	31	31			
	20	37	37	37	36	36	35	35	35			
Alt. Parts	24	41	41	41	40	40	39	39	39			
′ ″	28	45	45	45	44	44	43	43	43			
0 0	32	49	49	49	48	48	47	47	47			
1 1	36	53	53	53	52	51	51	51	50			
2 2	40	57	57	56	56	55	55	55	54			
3 3	44	46 1	47 1	48 0	49 0	59	59	59	58			
	48	4	4	3	3	50 2	51 2	52 2	53 1		1	1
	52	8	8	7	7	6	6	6	5		2	2
	56	11	11	10	10	9	9	9	8	10	3	3
	7 0	46 15	47 14	48 14	49 13	50 13	51 13	52 12	53 12	20	4	4
	4	18	17	17	16	16	16	15	15	30	5	5
	8	21	20	20	19	19	19	18	18	40	6	6
	12	25	24	24	23	23	22	22	21	50	7	7
	16	28	27	27	26	26	25	25	24		8	8
0 0	20	31	30	30	29	29	28	28	27		9	9
1 1	24	34	33	33	32	32	31	31	30			
2 2	28	37	36	36	35	35	34	34	33			
3 2	32	39	39	38	38	37	37	36	36			
	36	42	42	41	41	40	40	39	39			
	40	45	45	44	44	43	43	42	42			
	44	48	48	47	47	46	45	45	44			
	48	51	51	50	50	49	48	48	47			
	52	53	53	52	52	51	50	50	49			
	56	56	56	55	55	54	53	53	52			
	8 0	46 59	47 58	48 58	49 57	50 56	51 56	52 55	53 55			
	4	47 1	48 0	49 0	59	58	58	57	57			
	8	4	3	3	50 2	51 1	52 1	53 0	54 0			
	12	6	5	5	4	3	3	2	2			
	16	9	8	7	7	6	6	5	4			
0 0	20	11	10	9	9	8	8	7	6			
1 1	24	13	12	11	11	10	10	9	8			
2 1	28	15	15	14	13	13	12	11	11			
3 2	32	17	17	16	15	15	14	13	13			
	36	20	19	18	18	17	16	15	15			
	40	22	21	20	20	19	18	17	17			
	44	24	23	22	22	21	20	19	19		1	1
	48	26	25	24	24	23	22	21	21		2	2
	52	28	27	26	26	25	24	23	23	10	3	3
	56	29	29	28	27	27	26	25	24	20	4	4
	9 0	47 31	48 31	49 30	50 29	51 29	52 28	53 27	54 26	30	5	5
	4	33	33	32	31	31	30	29	28	39	6	6
	8	35	34	34	33	32	31	30	30	49	7	7
	12	37	36	36	35	34	33	32	32		8	8
	16	38	38	37	36	35	34	34	33		9	9
0 0	20	40	40	39	38	37	36	36	35			
1 0	24	42	42	41	40	39	38	38	37			
2 1	28	44	43	42	41	40	39	39	38			
3 1	32	46	45	44	43	42	41	41	40			
	36	47	46	45	44	43	42	42	41			
	40	48	47	47	46	45	44	43	43			
	44	50	49	48	48	47	46	45	44			
	48	51	50	49	49	48	47	46	45			
	52	53	52	51	51	50	49	48	47			
	56	54	53	52	52	51	50	49	48			

Auxiliary Arcs used in clearing the Lunar Distance.

Parts for Min. of ☽'s Alt. *Add*	☽'s App. Alt.	☽'s Horizontal Parallax. 54′	55′	56′	57′	58′	59′	60′	61′	Parts for Seconds of Parallax. *Add* Parts	Parallax.	Parts
	° ′	60°	60°	60°	60°	60°	60°	60°	60°			
	6 0	2′ 22″	2′ 26″	2′ 30″	2′ 34″	2′ 38″	2′ 42″	2′ 47″	2′ 51″	″	″	″
	4	24	28	32	36	40	44	49	53			
	8	27	31	35	39	43	47	52	56			
	12	29	33	37	41	45	49	54	58			
Alt. Parts	16	31	35	39	44	48	52	57	3 1			
′ ″	20	33	37	41	46	50	54	59	3			
0 0	24	35	39	43	48	52	56	3 1	5			
1 1	28	38	42	46	51	55	59	4	8			
2 1	32	40	44	48	53	57	3 1	6	10			
3 2	36	42	46	51	55	3 0	4	9	13			
	40	44	48	53	57	2	6	11	15			
	44	46	50	55	59	4	8	13	17			
	48	49	53	57	3 2	7	11	16	20		1	0
	52	51	55	59	4	9	13	18	22		2	0
	56	53	57	3 2	7	12	16	21	25	1	3	0
	7 0	2 55	2 59	3 4	3 9	3 14	3 18	3 23	3 28	2	4	0
	4	57	3 1	6	11	16	20	25	30	2	5	0
	8	59	4	9	14	19	23	28	33	3	6	0
	12	3 1	6	11	16	21	25	30	35	4	7	1
	16	4	8	13	18	23	28	33	38		8	1
0 0	20	6	10	15	20	25	30	35	40		9	1
1 1	24	8	12	17	22	27	32	37	42			
2 1	28	10	15	20	25	30	35	40	45			
3 2	32	12	17	22	27	32	37	42	47			
	36	14	19	24	30	35	40	45	50			
	40	16	21	26	32	37	42	47	52			
	44	18	23	28	34	39	44	49	54			
	48	21	26	31	36	41	46	52	57			
	52	23	28	33	38	43	48	54	59			
	56	25	30	35	41	46	51	57	4 2			
	8 0	3 27	3 32	3 37	3 43	3 48	3 54	3 59	4 4			
	4	29	34	39	45	50	56	4 1	6			
	8	32	37	42	48	53	59	4	9			
	12	34	39	44	50	55	4 1	6	11			
	16	36	41	46	52	58	4	9	14			
0 0	20	38	43	48	54	4 0	6	11	16			
1 1	24	40	45	50	56	2	8	13	19			
2 1	28	42	48	53	59	5	11	16	22			
3 2	32	44	50	55	4 1	7	13	18	24			
	36	46	52	58	4	9	15	21	27			
	40	48	54	4 0	6	11	17	23	29			
	44	50	56	2	8	13	19	25	31		1	0
	48	53	59	4	10	16	22	28	34		2	0
	52	55	4 1	6	12	18	24	30	36	1	3	0
	56	57	3	9	15	21	27	33	39	2	4	0
	9 0	3 59	4 5	4 11	4 17	4 23	4 29	4 35	4 41	3	5	1
	4	4 1	7	13	19	25	31	37	43	4	6	1
	8	3	10	16	22	28	34	40	46	5	7	1
	12	5	12	18	24	30	36	42	48		8	1
	16	8	14	20	26	32	39	45	51		9	1
0 0	20	10	16	22	28	34	41	47	53			
1 1	24	12	18	24	30	36	43	49	55			
2 1	28	14	21	27	33	39	46	52	58			
3 2	32	16	23	29	35	41	48	54	5 0			
	36	18	25	31	38	44	50	56	3			
	40	20	27	33	40	46	52	58	5			
	44	22	29	35	42	48	54	5 0	7			
	48	25	32	38	44	50	57	3	10			
	52	27	34	40	46	52	59	5	12			
	56	29	36	42	49	55	5 2	8	15			

Correction for Alt. of ☉ or ☿ *Add* ☉

°	″
3	8
4	5
5	4
6	3
7	2
8	2
9	2
10	2
20	2
30	3
40	3
50	4
60	4
70	5
80	5
90	5

☿

°	″
3	8
4	5
5	4
6	3
7	2
8	2
9	1
10	1
20	0
30	0
40	0
50	0
60	0
70	0
80	0
90	0

Correction of ☽'s Apparent Altitude.

Parts for Min. of Alt. *Add*		☽'s App. Alt.	☽'s Horizontal Parallax								Parts for Seconds of Parallax. *Add*			
			54′	55′	56′	57′	58′	59′	60′	61′	Parts	Parallax.		Parts
Alt.	Parts	° ′	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	″	″	″	″
		10 0	47 56	48 55	49 54	50 53	51 52	52 51	53 50	54 49				
		10	59	58	57	56	55	54	53	52				
′	″	20	48 2	49 1	50 0	58	58	57	56	55				
0	0	30	5	4	3	51 2	52 1	53 0	59	58			1	1
1	1	40	8	7	6	5	4	3	54 2	55 1			2	2
2	1	50	11	10	9	8	7	6	4	3	10	10	3	3
3	1										20	20	4	4
4	1	11 0	48 13	49 12	50 11	51 10	52 9	53 8	54 7	55 6	29	30	5	5
5	1	10	16	15	14	12	11	10	9	8	39	40	6	6
6	2	20	18	17	16	15	13	12	11	10	49	50	7	7
7	2	30	20	19	18	17	15	14	13	12			8	8
8	2	40	22	21	20	19	17	16	15	14			9	9
9	2	50	24	23	22	20	19	18	16	15				
		12 0	48 26	49 25	50 23	51 22	52 21	53 19	54 18	55 17				
0	0	10	27	26	25	23	22	21	19	18				
1	0	20	29	28	26	25	23	22	21	19			1	1
2	0	30	30	29	27	26	25	23	22	20			2	2
3	0	40	32	30	29	27	26	24	23	21	10	10	3	3
4	0	50	33	31	30	28	27	25	24	22	20	20	4	4
5	1	13 0	48 34	49 32	50 31	51 29	52 28	53 26	54 25	55 23	29	30	5	5
6	1	10	35	33	32	30	28	27	25	24	39	40	6	6
7	1	20	36	34	32	31	29	28	26	24	49	50	7	7
8	1	30	36	35	33	31	30	28	26	25			8	8
9	1	40	37	35	34	32	30	29	27	25			9	9
		50	38	36	34	32	31	29	27	25				
		14 0	48 38	49 36	50 35	51 33	52 31	53 29	54 27	55 26				
0	0	10	39	37	35	33	31	29	28	26				
1	0	20	39	37	35	33	31	30	28	26			1	1
2	0	30	39	37	35	33	31	30	28	26			2	2
3	0	40	39	37	35	33	31	30	28	26	10	10	3	3
4	0	50	39	37	35	33	31	29	27	25	19	20	4	4
5	0	15 0	48 39	49 37	50 35	51 33	52 31	53 29	54 27	55 25	29	30	5	5
6	0	10	39	37	35	33	31	29	27	25	39	40	6	6
7	0	20	39	37	35	33	31	28	26	24	48	50	7	7
8	0	30	39	37	34	32	30	28	26	24			8	8
9	0	40	39	36	34	32	30	27	25	23			9	9
		50	38	36	34	31	29	27	24	22				
		16 0	48 37	49 34	50 32	51 30	52 27	53 25	54 23	55 20				
0	1	10	36	34	31	29	27	24	22	20				
1	1	20	36	33	31	28	26	24	21	19			1	1
2	1	30	35	32	30	28	25	23	20	18			2	2
3	1	40	34	32	29	27	24	22	19	17	10	10	3	3
4	1	50	33	31	28	26	23	21	18	16	19	20	4	4
5	1	17 0	48 33	49 30	50 27	51 25	52 22	53 20	54 17	55 14	29	30	5	5
6	0	10	32	29	26	24	21	18	16	13	38	40	6	6
7	0	20	31	28	25	23	20	17	14	12	48	50	7	7
8	0	30	30	27	24	21	19	16	13	10			8	8
9	0	40	29	26	23	20	17	15	12	9			9	9
		50	28	25	22	19	16	14	10	7				
		18 0	48 26	49 23	50 21	51 18	52 15	53 12	54 9	55 6				
0	1	10	25	22	19	16	13	10	7	4				
1	1	20	24	21	18	15	12	9	6	3			1	1
2	1	30	22	19	16	13	10	7	4	1			2	2
3	1	40	21	18	15	12	8	5	2	54 58	9	10	3	3
4	1	50	20	16	13	10	7	4	0	57	19	20	4	4
5	1	19 0	48 17	49 14	50 11	51 7	52 4	53 1	53 58	54 54	28	30	5	5
6	1	10	16	12	9	6	2	52 59	56	52	38	40	6	6
7	0	20	14	11	7	4	0	57	54	50	47	50	7	7
8	0	30	12	9	5	2	51 59	55	52	48			8	8
9	0	40	11	7	4	0	57	53	50	46			9	9
		50	9	5	2	50 58	55	51	47	44				

Auxiliary Arcs used in clearing the Lunar Distance.

Parts for Min. of ☽'s Alt. *Add*		☽'s App. Alt.	☽'s Horizontal Parallax.								Parts for Seconds of Parallax. *Add*			
			54′	55′	56′	57′	58′	59′	60′	61′	Parts	Parallax.		Parts
			60°	60°	60°	60°	60°	60°	60°	60°				
Alt.	Parts	° ′	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	″	″	″	″
′	″	10 0	4 31	4 38	4 44	4 51	4 57	5 4	5 10	5 17				
		10	36	44	50	57	5 3	10	16	23				
0	0	20	42	49	55	5 2	9	16	22	29				
1	1	30	47	55	5 1	8	15	22	28	35			1	0
2	1	40	52	5 0	7	14	20	27	34	41			2	0
3	2	50	58	5	12	19	26	33	40	47	2	10	3	0
4	2	11 0	5 3	5 11	5 18	5 25	5 32	5 39	5 46	5 53	3	20	4	0
5	3	10	8	16	24	31	38	45	52	59	4	30	5	1
6	3	20	14	22	29	36	43	51	58	6 5	5	40	6	1
7	4	30	19	27	35	42	49	57	6 4	11	6	50	7	1
8	4	40	24	32	40	47	55	6 2	10	17			8	1
9	5	50	30	38	46	53	6 0	8	16	23			9	1
		12 0	5 35	5 43	5 51	5 58	6 6	6 14	6 22	6 29				
		10	40	48	56	6 4	12	20	28	35				
0	0	20	46	54	6 2	9	17	26	34	41			1	0
1	1	30	51	59	8	15	23	32	40	47			2	0
2	1	40	56	6 4	13	21	29	37	45	53	1	10	3	0
3	2	50	6 2	10	18	26	34	43	51	59	3	20	4	1
4	2	13 0	6 7	6 15	6 24	6 32	6 40	6 49	6 57	7 5	4	30	5	1
5	3	10	12	21	30	38	46	55	7 3	11	5	40	6	1
6	3	20	18	26	35	43	51	7 0	9	17	7	50	7	1
7	4	30	23	32	41	49	57	7 6	15	23			8	1
8	4	40	28	37	46	55	7 3	12	20	29			9	1
9	5	50	34	43	52	7 0	8	17	26	35				
		14 0	6 39	6 48	6 57	7 6	7 14	7 23	7 32	7 41				
		10	44	53	7 2	12	20	29	38	47				
0	0	20	50	59	8	17	25	35	44	53			1	0
1	1	30	55	7 4	13	23	31	41	50	59			2	0
2	1	40	7 0	9	18	28	37	46	55	8 5	2	10	3	0
3	2	50	6	15	24	33	42	52	8 1	11	3	20	4	1
4	2	15 0	7 11	7 20	7 29	7 39	7 48	7 58	8 7	8 17	5	30	5	1
5	3	10	16	25	35	45	54	8 4	13	23	6	42	6	1
6	3	20	21	31	40	50	59	9	19	29	8	50	7	1
7	4	30	27	36	46	56	8 5	15	25	35			8	1
8	4	40	32	41	51	8 1	11	21	30	40			9	1
9	5	50	37	47	57	7	16	26	36	46				
		16 0	7 42	7 52	8 2	8 12	8 22	8 32	8 42	8 52				
		10	47	57	7	18	28	38	48	58				
0	0	20	52	8 3	13	23	33	43	54	9 4			1	0
1	1	30	58	8	18	29	39	49	9 0	10			2	0
2	1	40	8 3	13	23	34	45	55	5	15	2	10	3	1
3	2	50	8	19	29	40	50	9 0	11	21	4	20	4	1
4	2	17 0	8 13	8 24	8 34	8 45	8 56	9 6	9 17	9 27	5	30	5	1
5	3	10	18	29	39	51	9 2	12	23	33	7	40	6	1
6	3	20	23	34	45	56	7	17	28	39	9	50	7	1
7	4	30	29	40	50	9 2	13	23	34	45			8	1
8	4	40	34	45	55	7	18	29	40	50			9	2
9	5	50	39	50	9 1	13	24	34	45	56				
		18 0	8 44	8 55	9 6	9 18	9 29	9 40	9 51	10 2				
		10	49	9 0	11	23	35	46	57	8				
0	0	20	54	6	17	29	40	51	10 2	14			1	0
1	1	30	9 0	11	22	34	46	57	8	20			2	0
2	1	40	5	16	27	39	51	10 3	14	25	2	10	3	1
3	2	50	10	22	33	45	57	8	19	31	4	20	4	1
4	2	19 0	9 15	9 27	9 38	9 50	10 2	10 14	10 25	10 37	6	30	5	1
5	3	10	20	32	43	55	8	20	31	43	8	40	6	1
6	3	20	25	37	49	10 1	13	25	37	49	10	50	7	1
7	4	30	31	43	54	6	19	31	43	55			8	2
8	4	40	36	48	59	11	24	36	48	11 0			9	2
9	5	50	41	53	10 5	17	30	42	53	11 6				

Correction for Alt. of ☉ or ✳ *Add*

☉

°	″
3	8
4	5
5	4
6	3
7	2
8	2
9	2
10	2
20	2
30	3
40	3
50	4
60	4
70	5
80	5
90	5

✳

°	″
3	8
4	5
5	4
6	3
7	2
8	2
9	1
10	1
20	0
30	0
40	0
50	0
60	0
70	0
80	0
90	0

Correction of ☽'s Apparent Altitude.

Parts for Min. of Alt. *Add*	☽'s App. Alt.	☽'s Horizontal Parallax. 54′	55′	56′	57′	58′	59′	60′	61′	Parts for Seconds of Parallax. *Add* Parts	Parallax.	Parts
Alt. Parts	° ′	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	″	″	″
	20 0	48 7	49 3	50 0	50 56	51 53	52 49	53 45	54 42			
	10	5	1	49 58	54	50	47	43	39			
0 2	20	3	48 59	56	52	48	44	41	37		1	1
1 2	30	1	57	54	50	46	42	38	35		2	2
2 2	40	47 59	55	51	48	44	40	36	32	9	3	3
3 2	50	57	53	49	45	42	38	34	30	19	4	4
4 1	21 0	47 55	48 51	49 47	50 43	51 39	52 35	53 31	54 27	28	5	5
5 1	10	53	49	45	41	37	33	29	25	37	6	6
6 1	20	51	47	43	38	34	30	26	22	47	7	7
7 1	30	49	44	40	36	32	28	24	19		8	7
8 0	40	46	42	38	34	29	25	21	17		9	8
9 0	50	44	40	35	31	27	23	18	14			
	22 0	47 41	48 36	49 32	50 28	51 23	52 19	53 15	54 10			
0 3	10	38	34	29	25	21	16	12	7			
1 3	20	36	31	27	22	18	13	9	4		1	1
2 2	30	33	29	24	20	15	11	6	1		2	2
3 2	40	31	26	22	17	12	8	3	53 58	9	3	3
4 2	50	28	24	19	14	10	5	0	55	18	4	4
5 1	23 0	47 26	48 21	49 16	50 11	51 7	52 2	52 57	53 52	28	5	5
6 1	10	23	18	13	9	4	51 59	54	49	37	6	6
7 1	20	20	16	11	6	1	56	51	46	46	7	6
8 1	30	18	13	8	3	50 58	53	48	43		8	7
9 0	40	15	10	5	0	55	50	45	40		9	8
	50	12	7	2	49 57	52	47	41	36			
	24 0	47 9	48 4	48 59	49 54	50 49	51 44	52 38	53 33			
0 3	10	7	1	56	51	45	40	35	30			
1 3	20	4	47 58	53	48	42	37	32	26		1	1
2 3	30	1	55	50	44	39	34	28	23		2	2
3 3	40	46 58	52	47	41	36	30	25	19	9	3	3
4 2	50	55	49	44	38	32	27	21	16	18	4	4
5 2	25 0	46 52	47 46	48 40	49 35	50 29	51 24	52 18	53 12	27	5	5
6 1	10	49	43	37	31	26	20	14	9	36	6	5
7 1	20	45	40	34	28	22	17	11	5	45	7	6
8 1	30	42	36	31	25	19	13	7	1		8	7
9 0	40	39	33	27	21	15	10	4	52 58		9	8
	50	36	30	24	18	12	6	0	54			
	26 0	46 33	47 27	48 20	49 14	50 8	51 2	51 56	52 50			
0 3	10	29	23	17	11	5	50 59	52	46			
1 3	20	26	20	14	7	1	55	49	42		1	1
2 3	30	23	16	10	4	49 57	51	45	38		2	2
3 3	40	19	13	6	0	54	47	41	35	9	3	3
4 2	50	16	9	3	48 56	50	43	37	31	18	4	4
5 2	27 0	46 12	47 6	47 59	48 53	49 46	50 40	51 33	52 27	27	5	4
6 1	10	9	2	56	49	42	36	29	23	36	6	5
7 1	20	5	46 59	52	45	39	32	25	18	45	7	6
8 1	30	2	55	48	41	36	28	21	14		8	7
9 0	40	45 58	51	44	37	31	24	17	10		9	8
	50	55	48	41	34	27	20	13	6			
	28 0	45 50	46 43	47 36	48 29	49 22	50 15	51 8	52 1			
0 3	10	46	39	32	25	18	11	4	51 56			
1 3	20	42	35	28	21	13	6	0	52		1	1
2 3	30	39	31	24	17	10	2	50 55	48		2	2
3 3	40	35	28	20	13	5	49 58	51	43	9	3	3
4 2	50	31	24	16	9	1	54	46	39	17	4	3
5 2	29 0	45 27	46 20	47 12	48 5	48 57	49 50	50 42	51 35	26	5	4
6 1	10	23	16	8	1	53	45	38	30	35	6	5
7 1	20	19	12	4	47 56	49	41	33	26	44	7	6
8 1	30	15	8	0	52	45	37	29	21		8	7
9 0	40	11	4	46 56	48	40	32	24	16		9	8
	50	8	0	52	44	36	28	20	12			

Auxiliary Arcs used in clearing the Lunar Distance.

Parts for Min. of ☽'s Alt. *Add.* Alt.	Parts	☽'s App. Alt.	☽'s Horizontal Parallax. 54′	55′	56′	57′	58′	59′	60′	61′	Parts for Seconds of Parallax. *Add* Parts	Parallax.	Parts
			60°	60°	60°	60°	60°	60°	60°	60°			
		° ′	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	″	″	″
		20 0	9 46	9 58	10 10	10 22	10 35	10 47	10 59	11 12			
		10	51	10 3	15	28	41	53	11 5	18			
–	=	20	56	8	21	34	46	58	10	23			
0	0	30	10 1	14	26	39	52	11 4	16	29		1	0
1	1	40	6	19	31	44	57	9	22	35		2	0
2	1	50	11	24	37	50	11 3	15	27	40		3	1
3	2	21 0	10 16	10 29	10 42	10 55	11 8	11 20	11 33	11 46	2	4	1
4	2	10	21	34	47	11 0	13	26	39	52	4	5	1
5	3	20	26	39	52	5	19	31	44	57	7	6	1
6	3	30	31	44	58	11	24	37	50	12 3	9	7	2
7	4	40	36	49	11 3	16	29	42	56	9	11	8	2
8	4	50	41	54	8	21	35	48	12 1	14		9	2
9	5	22 0	10 46	10 59	11 13	11 26	11 40	11 53	12 7	12 20			
		10	51	11 4	18	31	45	59	13	26			
0	0	20	56	9	23	37	51	12 4	18	31		1	0
1	1	30	11 1	15	29	42	56	10	24	37		2	0
2	1	40	6	20	34	47	12 1	15	29	43	2	3	1
3	2	50	11	25	39	53	7	21	35	48	5	4	1
4	2	23 0	11 16	11 30	11 44	11 58	12 12	12 26	12 40	12 54	7	5	1
5	3	10	21	35	49	12 3	17	32	46	13 0	9	6	1
6	3	20	26	40	54	9	23	37	51	5	12	7	2
7	4	30	31	45	12 0	14	28	43	57	11		8	2
8	4	40	36	50	5	19	33	48	13 2	17		9	2
9	5	50	41	55	10	25	39	54	8	22			
		24 0	11 46	12 0	12 15	12 30	12 44	12 59	13 13	13 28			
		10	51	5	20	35	49	13 4	19	34			
0	0	20	56	10	25	40	55	10	24	39		1	0
1	1	30	12 0	15	31	46	13 0	15	30	45		2	1
2	1	40	5	20	36	51	5	20	35	50	3	3	1
3	2	50	10	25	41	56	11	26	41	56	5	4	1
4	2	25 0	12 15	12 30	12 46	13 1	13 16	13 31	13 46	14 1	8	5	1
5	3	10	20	35	51	6	21	36	51	7	10	6	2
6	3	20	25	40	56	11	26	42	57	12	13	7	2
7	4	30	30	45	13 1	17	32	47	14 2	18		8	2
8	4	40	35	50	6	22	37	52	7	23		9	2
9	5	50	40	55	11	27	42	58	13	29			
		26 0	12 45	13 0	13 16	13 32	13 47	14 3	14 18	14 34			
		10	50	5	21	37	52	8	23	40			
0	0	20	55	10	26	42	57	13	29	45		1	0
1	1	30	13 0	15	31	47	14 3	19	34	51		2	1
2	1	40	4	20	36	52	8	24	39	56	3	3	1
3	2	50	9	25	41	57	13	29	45	15 2	5	4	1
4	2	27 0	13 14	13 30	13 46	14 2	14 18	14 34	14 50	15 7	8	5	1
5	3	10	19	35	51	7	23	39	55	12	11	6	2
6	3	20	24	40	56	12	28	45	15 1	18	13	7	2
7	4	30	29	45	14 1	17	34	50	6	23		8	2
8	4	40	33	49	6	22	39	55	11	28		9	2
9	5	50	38	54	11	27	44	15 1	17	34			
		28 0	13 43	13 59	14 16	14 32	14 49	15 6	15 22	15 39			
		10	48	14 4	21	37	54	11	27	44			
0	0	20	52	9	26	42	59	16	33	50		1	0
1	1	30	57	14	31	47	15 4	22	38	55		2	1
2	1	40	14 2	18	35	52	9	27	43	16 0	3	3	1
3	2	50	6	23	40	57	14	32	49	6	6	4	1
4	2	29 0	14 11	14 28	14 45	15 2	15 19	15 37	15 54	16 11	9	5	1
5	3	10	16	33	50	7	24	42	59	16	11	6	2
6	3	20	20	38	55	12	29	47	16 4	22	14	7	2
7	4	30	25	43	15 0	17	35	53	10	27		8	2
8	4	40	30	47	4	22	40	58	15	32		9	3
9	5	50	34	52	9	27	45	16 3	20	38			

Correction for Alt. of ⊙ or ✳ *Add* ⊙

°	″
3	8
4	5
5	4
6	3
7	2
8	2
9	2
10	2
20	2
30	3
40	3
50	4
60	4
70	5
80	5
90	5

✳

°	″
3	8
4	5
5	4
6	3
7	2
8	2
9	1
10	1
20	0
30	0
40	0
50	0
60	0
70	0
80	0
90	0

Correction of ☽'s Apparent Altitude.

Parts for Min. of Alt. *Add*		☽'s App. Alt.	☽'s Horizontal Parallax. 54′	55′	56′	57′	58′	59′	60′	61′	Parts for Seconds of Parallax. *Add* Parallax.	Parts
Alt.	Parts	° ′	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″		
		30 0	45 3	45 55	46 47	47 39	48 31	49 23	50 15	51 7		
		10	44 59	51	43	35	27	19	11	3		
′	″	20	55	47	39	31	22	14	6	50 58		
0	5	30	51	43	35	26	18	10	1	53		
1	4	40	47	39	30	22	13	5	49 57	48		
2	4	50	43	34	26	17	9	0	52	43		
3	3	31 0	44 38	45 29	46 20	47 12	48 3	48 55	49 46	50 38		
4	3	10	33	25	16	7	47 59	50	41	33		
5	2	20	29	20	12	3	55	45	37	28		
6	2	30	25	16	7	46 58	49	41	32	23		
7	1	40	20	11	3	54	45	36	27	18		
8	1	50	16	7	45 58	49	40	31	22	13		
9	0	32 0	44 12	45 3	45 53	46 45	47 35	48 26	49 17	50 8		
		10	7	44 58	49	40	30	21	12	3		
0	5	20	3	53	45	35	26	16	7	49 58		
1	4	30	43 58	49	40	30	21	11	2	53		
2	4	40	53	45	35	25	16	6	48 57	47		
3	3	50	49	40	30	21	11	1	52	42		
4	3	33 0	43 45	44 35	45 25	46 16	47 6	47 56	48 47	49 37		
5	2	10	40	30	21	11	1	51	41	32		
6	2	20	35	26	16	6	46 56	46	36	26		
7	1	30	31	21	11	1	51	41	31	21		
8	1	40	26	16	6	45 56	46	36	26	16		
9	0	50	21	11	1	51	41	31	21	10		
		34 0	43 17	44 7	44 56	45 46	46 36	47 25	48 15	49 5		
		10	12	2	51	41	31	20	10	0		
0	5	20	7	43 57	46	36	25	15	4	48 54		
1	5	30	2	52	41	31	20	10	47 59	49		
2	4	40	42 58	47	36	26	15	4	54	43		
3	4	50	53	42	31	20	10	46 59	48	37		
4	3	35 0	42 48	43 37	44 26	45 15	46 4	46 54	47 43	48 32		
5	3	10	43	32	21	10	45 59	48	37	26		
6	2	20	38	27	16	5	55	43	32	21		
7	2	30	33	22	11	0	48	37	26	15		
8	1	40	28	17	5	44 55	43	32	20	9		
9	1	50	23	12	0	49	38	26	15	3		
		36 0	42 18	43 6	43 55	44 44	45 32	46 21	47 9	47 58		
		10	13	1	50	38	27	15	3	52		
0	5	20	8	42 56	45	33	21	9	46 58	46		
1	5	30	3	51	39	27	16	4	52	40		
2	5	40	41 57	46	35	22	10	45 58	46	34		
3	4	50	52	40	28	16	4	52	40	28		
4	3	37 0	41 46	42 34	43 22	44 10	44 57	45 46	46 34	47 22		
5	3	10	41	29	16	4	52	40	28	16		
6	2	20	36	23	11	43 59	46	34	22	10		
7	2	30	30	18	5	53	41	28	16	3		
8	1	40	25	12	0	47	36	22	10	46 57		
9	1	50	20	7	42 54	42	29	17	4	51		
		38 0	41 14	42 2	42 49	43 36	44 23	45 11	45 58	46 45		
		10	9	41 56	43	30	18	5	52	39		
0	6	20	4	51	38	26	12	44 59	46	33		
1	5	30	40 58	46	32	19	6	53	40	27		
2	5	40	53	39	26	13	0	47	34	21		
3	4	50	47	34	21	7	43 54	41	28	14		
4	3	39 0	40 42	41 28	42 15	43 2	43 48	44 35	45 21	46 8		
5	3	10	35	23	9	42 56	42	29	15	2		
6	2	20	31	17	3	50	36	23	9	45 55		
7	2	30	25	11	41 58	44	30	16	3	49		
8	1	40	19	6	52	38	24	10	44 57	43		
9	1	50	14	0	46	32	18	4	50	36		

Parts	Parallax.	Parts
″	″	″ ″
		1 1
		2 2
9	10	3 3
17	20	4 3
26	30	5 4
34	40	6 5
43	50	7 6
		8 7
		9 8
		1 1
		2 2
8	10	3 3
17	20	4 3
25	30	5 4
33	40	6 5
42	50	7 6
		8 7
		9 8
		1 1
		2 2
8	10	3 2
16	20	4 3
24	30	5 4
33	40	6 5
41	50	7 6
		8 7
		9 7
		1 1
		2 2
8	10	3 2
16	20	4 3
24	30	5 4
32	40	6 5
40	50	7 6
		8 6
		9 7
		1 1
		2 2
8	10	3 2
16	20	4 3
23	30	5 4
31	40	6 5
39	50	7 5
		8 6
		9 7

Auxiliary Arcs used in clearing the Lunar Distance.

Parts for Min. of ☽'s Alt. *Add*	☽'s App. Alt.	☽'s Horizontal Parallax.								Parts for Seconds of Parallax. *Add*			
		54′	55′	56′	57′	58′	59′	60′	61′				
		60°	60°	60°	60°	60°	60°	60°	60°	Parts	Parallax.	Parts	
Alt. Parts	° ′	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	″	″	″	″
	30 0	14 39	14 57	15 14	15 32	15 50	16 8	16 25	16 42				
	10	44	15 2	19	37	55	13	30	48				
′ ″	20	48	6	24	42	16 0	18	35	53				
0 0	30	53	11	29	47	5	23	41	59			1	0
1 0	40	58	16	33	51	10	28	46	17 4			2	1
2 1	50	15 2	20	38	56	15	33	51	9	3	10	3	1
3 1										6	20	4	1
4 2	31 0	15 7	15 25	15 43	16 1	16 20	16 38	16 56	17 14	9	30	5	2
5 2	10	12	30	48	6	25	43	17 1	19	12	40	6	2
6 3	20	16	34	53	11	30	48	6	24	15	50	7	2
7 3	30	21	39	58	16	35	53	12	30			8	2
8 4	40	25	44	16 2	20	39	58	17	35			9	3
9 4	50	30	48	7	25	44	17 3	22	40				
	32 0	15 34	15 53	16 12	16 30	16 49	17 8	17 27	17 45				
0 0	10	39	58	17	35	54	13	32	50				
1 0	20	43	16 2	21	40	59	18	37	55			1	0
2 1	30	48	7	26	45	17 4	23	42	18 1			2	1
3 1	40	53	12	31	49	8	28	47	6	3	10	3	1
4 2	50	57	16	35	54	13	33	52	11	6	20	4	1
5 2	33 0	16 2	16 21	16 40	16 59	17 18	17 38	17 57	18 16	10	30	5	2
6 3	10	7	26	45	17 4	23	43	18 2	21	13	40	6	2
7 3	20	11	30	49	9	28	48	7	26	16	50	7	2
8 4	30	16	35	54	14	33	53	12	31			8	3
9 4	40	20	39	59	18	37	57	17	36			9	3
	50	25	44	17 3	23	42	18 2	22	41				
	34 0	16 29	16 48	17 8	17 28	17 47	18 7	18 27	18 46				
0 0	10	33	53	13	33	52	12	32	51				
1 0	20	38	57	17	37	57	17	37	56			1	0
2 1	30	42	17 2	22	42	18 2	22	42	19 1			2	1
3 1	40	46	6	26	47	6	26	46	6	3	10	3	1
4 2	50	51	11	31	51	11	31	51	11	7	20	4	1
5 2	35 0	16 55	17 15	17 35	17 56	18 16	18 36	18 56	19 16	10	30	5	2
6 3	10	59	20	40	18 1	21	41	19 1	21	13	40	6	2
7 3	20	17 4	24	44	5	25	46	6	26	17	50	7	2
8 4	30	8	29	49	10	30	51	11	31			8	3
9 4	40	12	33	54	14	35	55	15	36			9	3
	50	17	38	58	19	39	19 0	20	41				
	36 0	17 21	17 42	18 3	18 23	18 44	19 5	19 25	19 46				
0 0	10	25	47	8	28	49	10	30	51				
1 0	20	30	51	12	32	53	14	35	56			1	0
2 1	30	34	56	17	37	58	19	40	20 1			2	1
3 1	40	38	18 0	21	42	19 3	24	44	5	3	10	3	1
4 2	50	43	5	26	46	7	28	49	10	7	20	4	1
5 2	37 0	17 47	18 9	18 30	18 51	19 12	19 33	19 54	20 15	10	30	5	2
6 3	10	51	13	34	56	17	38	59	20	14	40	6	2
7 3	20	56	18	39	19 0	21	42	20 4	25	18	50	7	2
8 4	30	18 0	22	43	5	26	47	9	30			8	3
9 4	40	4	26	47	9	31	52	13	34			9	3
	50	9	31	52	14	35	56	18	39				
	38 0	18 13	18 35	18 56	19 18	19 40	20 1	20 23	20 44				
0 0	10	17	39	19 0	22	44	6	28	49				
1 0	20	21	43	5	27	49	10	32	54			1	0
2 1	30	26	48	9	31	54	15	37	59			2	1
3 1	40	30	52	13	35	58	20	42	21 3	4	10	3	1
4 2	50	34	56	18	40	20 2	24	46	8	7	20	4	1
5 2	39 0	18 38	19 0	19 22	19 44	20 7	20 29	20 51	21 13	11	30	5	2
6 3	10	42	4	26	49	11	34	56	18	15	40	6	2
7 3	20	46	8	31	53	16	38	21 0	22	18	50	7	3
8 4	30	51	13	35	58	20	43	5	27			8	3
9 4	40	55	17	39	20 2	24	47	10	32			9	3
	50	59	22	44	7	29	52	14	36				

Correction for Alt. of ☉ or ♃ *Add* ☉

°	″
3	8
4	5
5	4
6	3
7	2
8	2
9	2
10	2
20	2
30	3
40	3
50	4
60	4
70	5
80	5
90	5

♃

°	″
3	8
4	5
5	4
6	3
7	2
8	2
9	1
10	1
20	0
30	0
40	0
50	0
60	0
70	0
80	0
90	0

Correction of ☽'s Apparent Altitude.

Parts for Min. of Alt. *Add*		☽'s App. Alt.	☽'s Horizontal Parallax. 54′	55′	56′	57′	58′	59′	60′	61′
Alt.	Parts	° ′	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″
		40 0	40 8	40 54	41 40	42 26	43 12	43 58	44 44	45 30
		10	2	48	34	20	6	52	38	23
′	″									
0	6	20	39 57	43	28	14	0	45	31	16
1	6	30	51	37	22	8	42 54	39	25	10
2	5	40	45	31	16	2	47	33	18	4
3	4	50	40	25	10	41 56	41	27	12	44 57
4	4	41 0	39 34	40 19	41 4	41 50	42 35	43 20	44 5	44 51
5	3	10	28	13	40 58	43	29	14	43 59	44
6	2	20	22	7	52	37	22	7	52	37
7	2	30	16	1	46	31	16	1	46	30
8	1	40	10	39 55	40	25	10	42 55	39	24
9	1	50	4	49	34	19	3	48	33	17
		42 0	38 59	39 43	40 28	41 12	41 57	42 41	43 26	44 11
0	6	10	53	37	22	6	51	35	19	4
1	6	20	47	31	15	0	44	28	13	43 57
2	5	30	41	25	9	40 53	38	22	6	50
3	5	40	35	19	3	47	31	15	42 59	43
4	4	50	29	13	39 57	41	25	9	53	37
5	3	43 0	38 23	39 6	39 50	40 34	41 18	42 2	42 46	43 30
6	3	10	16	0	44	28	12	41 55	39	23
7	2	20	10	38 54	38	21	5	49	32	16
8	1	30	4	48	31	15	40 58	42	25	9
9	1	40	37 58	41	25	8	52	35	18	2
		50	52	35	18	2	45	28	12	42 55
		44 0	37 45	38 28	39 11	39 54	40 37	41 22	42 4	42 46
0	7	10	39	22	5	48	31	14	41 57	40
1	6	20	32	15	38 58	41	24	7	50	33
2	5	30	26	9	52	35	17	0	43	26
3	5	40	20	2	47	29	10	40 53	36	18
4	4	50	13	37 56	39	21	4	46	29	11
5	3	45 0	37 7	37 50	38 32	39 14	39 57	40 39	41 22	42 4
6	3	10	1	43	25	8	50	32	15	41 57
7	2	20	36 54	36	19	1	43	24	7	50
8	1	30	48	30	12	38 54	36	17	0	42
9	1	40	42	24	5	47	29	11	40 53	35
		50	35	17	37 59	41	22	4	46	29
		46 0	36 29	37 10	37 52	38 34	39 15	39 57	40 39	41 20
0	7	10	22	4	45	27	8	50	32	13
1	6	20	16	36 57	39	20	1	43	24	6
2	5	30	9	51	32	13	38 54	36	17	40 58
3	5	40	3	44	25	6	47	29	10	51
4	4	50	35 56	37	18	37 59	40	21	2	43
5	3	47 0	35 50	36 31	37 11	37 52	38 33	39 14	39 55	40 36
6	3	10	43	24	5	45	26	7	48	29
7	2	20	36	17	36 58	38	19	0	40	21
8	1	30	30	10	51	31	12	38 52	33	13
9	1	40	23	3	44	24	5	45	25	6
		50	16	35 56	37	17	37 58	38	18	39 58
		48 0	35 10	35 50	36 30	37 10	37 50	38 30	39 11	39 51
0	7	10	3	43	23	3	43	23	3	43
1	7	20	34 56	36	16	36 56	36	16	38 56	35
2	6	30	49	29	9	49	29	8	48	28
3	5	40	43	22	2	42	21	1	40	20
4	4	50	36	15	35 55	34	14	37 53	33	12
5	4	49 0	34 29	35 8	35 48	36 27	37 7	37 46	38 25	39 5
6	3	10	22	2	41	20	36 59	38	18	38 57
7	2	20	15	34 55	34	13	52	31	10	49
8	1	30	9	48	27	5	44	23	2	41
9	1	40	2	41	19	35 58	37	16	37 55	34
		50	33 55	32	12	51	30	8	47	26

Parts for Seconds of Parallax. *Add*

Parts	Parallax.		Parts
″	″	″	″
		1	1
		2	1
7	10	3	2
15	20	4	3
22	30	5	4
30	40	6	4
37	50	7	5
		8	6
		9	7
		1	1
		2	1
7	10	3	2
15	20	4	3
22	30	5	4
29	40	6	4
37	50	7	5
		8	6
		9	7
		1	1
		2	1
7	10	3	2
14	20	4	3
21	30	5	4
28	40	6	4
35	50	7	5
		8	6
		9	6
		1	1
		2	1
7	10	3	2
14	20	4	3
21	30	5	3
27	40	6	4
34	50	7	5
		8	5
		9	6
		1	1
		2	1
7	10	3	2
13	20	4	3
20	30	5	3
26	40	6	4
33	50	7	5
		8	5
		9	6

Auxiliary Arcs used in clearing the Lunar Distance.

Parts for Min. of ☽'s Alt. *Add*	☽'s App. Alt.	☽'s Horizontal Parallax.							
		54′	55′	56′	57′	58′	59′	60′	61′
		60°	60°	60°	60°	60°	60°	60°	60°
Alt. / Parts	° ′	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″
	40 0	19 3	19 26	19 48	20 11	20 33	20 56	21 19	21 41
	10	7	30	52	15	38	21 1	24	46
′ ″	20	11	34	57	20	42	5	28	50
1 0	30	16	39	20 1	24	47	10	33	55
2 1	40	20	43	5	28	51	14	37	22 0
3 1	50	24	47	10	33	56	19	42	4
4 2	41 0	19 28	19 51	20 14	20 37	21 0	21 23	21 46	22 9
5 2	10	32	55	18	41	4	27	51	14
6 3	20	36	59	22	45	9	32	55	18
7 3	30	40	20 3	27	50	13	36	22 0	23
8 4	40	44	7	31	54	17	40	4	27
9 4	50	48	11	35	58	22	45	9	31
	42 0	19 52	20 15	20 39	21 2	21 26	21 49	22 13	22 36
	10	56	19	43	6	30	53	17	41
0 0	20	20 0	23	47	10	34	58	22	45
1 0	30	4	27	51	15	39	22 2	26	50
2 1	40	8	31	55	19	43	6	30	54
3 1	50	12	35	59	23	47	11	35	59
4 2	43 0	20 16	20 39	21 3	21 27	21 51	22 15	22 39	23 3
5 2	10	20	43	7	31	55	19	43	7
6 3	20	24	47	11	35	59	23	48	12
7 3	30	28	51	15	40	22 4	28	52	16
8 4	40	31	55	19	44	8	32	56	20
9 4	50	35	59	23	48	12	36	23 1	25
	44 0	20 39	21 3	21 27	21 52	22 16	22 40	23 5	23 29
	10	43	7	31	56	20	44	9	33
0 0	20	47	11	35	22 0	24	48	13	37
1 0	30	51	15	39	4	29	53	18	42
2 1	40	54	19	43	8	33	57	22	46
3 1	50	58	23	47	12	37	23 1	26	51
4 2	45 0	21 2	21 27	21 51	22 16	22 41	23 5	23 30	23 55
5 2	10	6	31	55	20	45	9	34	59
6 2	20	9	35	59	24	49	13	38	24 3
7 3	30	13	39	22 3	28	53	18	43	8
8 3	40	17	42	7	32	57	22	47	12
9 4	50	20	46	11	36	23 1	26	51	16
	46 0	21 24	21 50	22 15	22 40	23 5	23 30	23 55	24 20
	10	28	54	19	44	9	34	59	24
0 0	20	31	57	23	48	13	38	24 3	28
1 0	30	35	22 1	27	52	17	42	8	33
2 1	40	39	5	30	55	21	46	12	37
3 1	50	42	8	34	59	25	50	16	41
4 2	47 0	21 46	22 12	22 38	23 3	23 29	23 54	24 20	24 45
5 2	10	50	16	42	7	33	58	24	49
6 2	20	53	19	45	11	37	24 2	28	53
7 3	30	57	23	49	15	41	6	32	58
8 3	40	22 1	27	53	18	44	10	36	25 2
9 4	50	4	30	56	22	48	14	40	6
	48 0	22 8	22 34	23 0	23 26	23 52	24 18	24 44	25 10
	10	12	38	4	30	56	22	48	14
0 0	20	15	41	7	34	24 0	26	52	18
1 0	30	19	45	11	38	4	30	56	22
2 1	40	23	49	15	41	7	33	25 0	26
3 1	50	26	52	18	45	11	37	4	30
4 2	49 0	22 30	22 56	23 22	23 49	24 15	24 41	25 8	25 34
5 2	10	34	23 0	26	53	19	45	12	38
6 2	20	37	3	29	56	22	49	16	42
7 3	30	41	7	33	24 0	26	53	20	46
8 3	40	44	10	37	4	30	56	23	49
9 4	50	48	14	40	7	33	25 0	27	53

Parts for Seconds of Parallax. *Add*			
Parts	Parallax.		Parts
″	″	″	″
		1	0
		2	1
4	10	3	1
8	20	4	1
11	30	5	2
15	40	6	2
19	50	7	3
		8	3
		9	3
		1	0
		2	1
4	10	3	1
8	20	4	2
12	30	5	2
16	40	6	2
20	50	7	3
		8	3
		9	4
		1	0
		2	1
4	10	3	1
8	20	4	2
12	30	5	2
17	40	6	2
21	50	7	3
		8	3
		9	4
		1	0
		2	1
4	10	3	1
9	20	4	2
13	30	5	2
17	40	6	3
21	50	7	3
		8	3
		9	4
		1	0
		2	1
4	10	3	1
9	20	4	2
13	30	5	2
18	40	6	3
22	50	7	3
		8	4
		9	4

Correction for Alt. of ☉ or ✳ *Add* ☉

°	″
3	8
4	5
5	4
6	3
7	2
8	2
9	2
10	2
20	2
30	3
40	3
50	4
60	4
70	5
80	5
90	5

✳

°	″
3	8
4	5
5	4
6	3
7	2
8	2
9	1
10	1
20	0
30	0
40	0
50	0
60	0
70	0
80	0
90	0

Correction of ☽'s Apparent Altitude.

Parts for Min. of Alt. *Add*	☽'s App. Alt.	☽'s Horizontal Parallax. 54′	55′	56′	57′	58′	59′	60′	61′	Parts for Seconds of Parallax. *Add* Parts	Parallax.	Parts
Alt. Parts	° ′	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	″	″	″
	50 0	33 48	34 26	35 5	35 44	36 22	37 1	37 39	38 18			
	10	41	19	34 58	36	15	36 53	32	10			
′ ″	20	34	12	51	29	7	45	24	2			1 1
0 8	30	27	5	43	21	0	38	16	37 54			2 1
1 7	40	20	33 58	36	14	35 52	30	8	46			3 2
2 6	50	13	51	29	7	45	22	0	38	6	10	4 2
3 5	51 0	33 6	33 44	34 21	34 59	35 37	36 15	36 52	37 30	13	20	5 3
4 5	10	32 59	36	14	52	29	7	45	22	19	30	6 4
5 4	20	52	29	7	44	22	35 59	37	14	25	40	7 4
6 3	30	45	22	33 59	37	14	51	29	6	32	50	8 5
7 2	40	38	15	52	29	6	43	21	36 58			9 6
8 1	50	30	7	45	22	34 59	35	13	50			
9 1	52 0	32 22	32 59	33 36	34 13	34 50	35 27	36 4	36 41			
	10	15	52	29	5	42	19	35 56	33			
0 8	20	8	45	21	33 58	35	11	48	25			1 1
1 7	30	1	37	14	50	27	3	40	16			2 1
2 6	40	31 53	30	6	43	19	34 55	32	8	6	10	3 2
3 5	50	46	22	32 59	35	11	47	24	0	12	20	4 2
4 5	53 0	31 39	32 15	32 51	33 27	34 3	34 40	35 16	35 52	18	30	5 3
5 4	10	32	8	44	20	33 56	32	7	43	24	40	6 4
6 3	20	24	0	36	12	48	24	34 59	35	30	50	7 4
7 2	30	17	31 53	28	4	40	16	51	27			8 5
8 2	40	10	45	21	32 56	32	7	43	19			9 5
9 1	50	2	38	13	49	24	33 59	35	10			
	54 0	30 55	31 30	32 5	32 41	33 16	33 51	34 27	35 2			
	10	48	23	31 58	33	8	43	18	34 54			
C 8	20	40	15	50	25	0	35	10	45			1 1
1 7	30	33	8	43	17	32 52	27	2	37			2 1
2 6	40	25	0	35	10	44	19	33 54	28	6	10	3 2
3 6	50	18	30 53	27	2	36	11	46	20	11	20	4 2
4 5	55 0	30 11	30 45	31 19	31 54	32 28	33 3	33 37	34 11	17	30	5 3
5 4	10	3	38	12	46	20	32 54	29	3	23	40	6 3
6 3	20	29 56	30	4	38	12	46	20	33 54	29	50	7 4
7 2	30	48	22	30 56	30	4	38	12	46			8 5
8 1	40	40	14	48	22	31 56	30	4	37			9 5
9 1	50	33	7	39	14	48	21	32 55	29			
	56 0	29 25	29 59	30 32	31 6	31 40	32 13	32 47	33 20			
	10	18	51	25	30 58	31	5	38	12			
0 8	20	10	43	17	50	23	31 56	30	3			1 1
1 7	30	3	36	9	42	15	48	21	32 54			2 1
2 6	40	28 55	28	1	34	7	40	13	46	5	10	3 2
3 6	50	47	20	29 53	26	30 59	31	4	37	11	20	4 2
4 5	57 0	28 40	29 12	29 45	30 18	30 50	31 23	31 56	32 28	16	30	5 3
5 4	10	32	4	37	10	42	15	47	20	22	40	6 3
6 3	20	24	28 57	29	1	34	6	39	11	27	50	7 4
7 2	30	17	49	21	29 53	26	30 58	30	2			8 4
8 2	40	9	41	13	45	17	49	21	31 53			9 5
9 1	50	1	33	5	37	9	41	13	45			
	58 0	27 53	28 25	28 57	29 29	30 1	30 32	31 4	31 36			
	10	46	17	49	21	29 52	24	30 55	27			
0 8	20	38	9	41	12	44	15	47	18			1 1
1 7	30	30	1	33	4	35	7	38	9			2 1
2 6	40	22	27 53	25	28 56	27	29 58	29	1	5	10	3 2
3 6	50	14	45	16	47	19	50	21	30 52	10	20	4 2
4 5	59 0	27 7	27 37	28 8	28 39	29 10	29 41	30 12	30 43	15	30	5 3
5 4	10	26 59	29	0	31	2	32	3	34	20	40	6 3
6 3	20	51	21	27 52	23	28 53	24	29 54	25	25	50	7 4
7 2	30	43	13	43	14	45	15	46	16			8 4
8 2	40	35	5	36	6	36	6	37	7			9 5
9 1	50	27	26 57	27	27 58	28	28 58	28	29 58			

Auxiliary Arcs used in clearing the Lunar Distance.

Parts for Min. of ☽'s Alt. *Add*		☽'s App. Alt.	☽'s Horizontal Parallax.							
			54′	55′	56′	57′	58′	59′	60′	61′
			60°	60°	60°	60°	60°	60°	60°	60°
Alt.	Parts	° ′	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″
		50 0	22 51	23 17	23 44	24 11	24 37	25 4	25 31	25 57
		10	54	21	48	15	41	8	35	26 1
′	″	20	58	24	51	18	44	11	38	5
1	0	30	23 1	28	55	22	48	15	42	9
2	1	40	4	31	58	25	52	19	46	12
3	1	50	8	35	24 2	29	55	22	49	16
4	1	51 0	23 11	23 38	24 5	24 32	24 59	25 26	25 53	26 20
5	2	10	14	42	9	36	25 3	30	57	24
6	2	20	18	45	12	39	6	33	26 0	28
7	2	30	21	49	16	43	10	37	4	32
8	3	40	24	52	19	46	14	41	8	35
9	3	50	28	56	23	50	17	44	11	39
		52 0	23 31	23 59	24 26	24 53	25 21	25 48	26 15	26 43
0	0	10	34	24 2	29	57	25	52	19	47
1	0	20	38	6	33	25 0	28	55	23	50
2	1	30	41	9	36	4	32	59	26	54
3	1	40	44	12	39	7	35	26 3	30	58
4	1	50	47	16	43	11	39	6	33	27 1
5	2	53 0	23 51	24 19	24 46	25 14	25 42	26 10	26 37	27 5
6	2	10	54	22	49	17	45	13	41	9
7	2	20	57	25	53	21	49	17	44	12
8	3	30	24 1	29	56	24	52	20	48	16
9	3	40	4	32	59	27	55	23	52	20
		50	7	35	25 3	31	59	27	55	23
		54 0	24 10	24 38	25 6	25 34	26 2	26 31	26 59	27 27
0	0	10	13	41	9	37	5	34	27 3	31
1	0	20	16	44	12	41	9	38	6	34
2	1	30	20	48	16	44	12	41	10	38
3	1	40	23	51	19	47	15	44	13	41
4	1	50	26	54	22	51	19	48	17	45
5	2	55 0	24 29	24 57	25 25	25 54	26 22	26 51	27 20	27 48
6	2	10	32	25 0	28	57	25	54	23	51
7	2	20	35	3	31	26 0	29	58	27	55
8	3	30	38	7	35	4	32	27 1	30	58
9	3	40	41	10	38	7	35	4	33	28 1
		50	44	13	41	10	39	8	37	5
		56 0	24 47	25 16	25 44	26 13	26 42	27 11	27 40	28 8
0	0	10	50	19	47	16	45	14	43	11
1	0	20	53	22	50	19	48	17	46	15
2	1	30	56	25	54	23	52	21	50	18
3	1	40	59	28	57	26	55	24	53	21
4	1	50	25 2	31	26 0	29	58	27	56	25
5	2	57 0	25 5	25 34	26 3	26 32	27 1	27 30	27 59	28 28
6	2	10	8	37	6	35	4	33	28 2	31
7	2	20	11	40	9	38	7	36	5	35
8	2	30	14	43	12	41	10	40	9	38
9	3	40	16	45	15	44	13	43	12	41
		50	19	48	18	47	16	46	15	45
		58 0	25 22	25 51	26 21	26 50	27 19	27 49	28 18	28 48
0	0	10	25	54	24	53	22	52	21	51
1	0	20	27	57	27	56	25	55	24	54
2	1	30	30	26 0	30	59	28	58	28	58
3	1	40	33	2	32	27 2	31	28 1	31	29 1
4	1	50	35	5	35	5	34	4	34	4
5	2	59 0	25 38	26 8	26 38	27 8	27 37	28 7	28 37	29 7
6	2	10	41	11	41	11	40	10	40	10
7	2	20	44	14	44	14	43	13	43	13
8	2	30	47	17	47	17	46	16	46	16
9	3	40	49	19	49	19	49	19	49	19
		50	52	22	52	22	52	22	52	22

Parts for Seconds of Parallax. *Add*			
Parts	Parallax.		Parts
″	″	″	″
		1	0
		2	1
5	10	3	1
9	20	4	2
14	30	5	2
18	40	6	3
23	50	7	3
		8	4
		9	4
		1	0
		2	1
5	10	3	1
9	20	4	2
14	30	5	2
19	40	6	3
23	50	7	3
		8	4
		9	4
		1	0
		2	1
5	10	3	1
10	20	4	2
14	30	5	2
19	40	6	3
24	50	7	3
		8	4
		9	4
		1	0
		2	1
5	10	3	1
10	20	4	2
15	30	5	2
19	40	6	3
24	50	7	3
		8	4
		9	4
		1	0
		2	1
5	10	3	1
10	20	4	2
15	30	5	2
20	40	6	3
25	50	7	3
		8	4
		9	4

Correction for Alt. of ☉ or ✳ *Add* ☉

°	″
3	8
4	5
5	4
6	3
7	2
8	2
9	2
10	2
20	2
30	3
40	3
50	4
60	4
70	5
80	5
90	5

✳

°	″
3	8
4	5
5	4
6	3
7	2
8	2
9	1
10	1
20	0
30	0
40	0
50	0
60	0
70	0
80	0
90	0

Correction of ☽'s Apparent Altitude.

Parts for Min. of Alt. *Add*	☽'s App. Alt.	☽'s Horizontal Parallax.								Parts for Seconds of Parallax. *Add*			
		54′	55′	56′	57′	58′	59′	60′	61′	Parts	Parallax.		Parts
Alt. Parts	° ′	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	″	″	″	″
′ ″	60 0	26 19	26 49	27 19	27 49	28 19	28 49	29 19	29 49				
0 9	10	11	41	11	41	11	40	11	40				
1 8	20	3	33	3	32	2	32	1	31			1	0
2 7	30	25 55	25	26 54	24	27 53	23	28 52	22			2	1
3 6	40	47	17	46	15	45	14	44	13	5	10	3	1
4 5	50	39	8	38	7	36	5	35	4	10	20	4	2
5 4	61 0	25 31	26 0	26 29	26 58	27 28	27 57	28 26	28 55	15	30	5	2
6 3	10	23	25 52	21	50	19	48	17	46	20	40	6	3
7 3	20	15	44	13	41	10	39	8	37	24	50	7	3
8 2	30	7	36	4	33	2	30	27 59	27			8	4
9 1	40	24 59	27	25 56	24	27 53	21	50	18			9	4
	50	51	19	48	16	44	13	41	9				
	62 0	24 42	25 10	25 38	26 6	26 34	27 3	27 31	27 59				
0 9	10	34	2	30	25 58	26	26 54	22	50			1	0
1 8	20	26	24 53	21	49	17	45	13	41			2	1
2 7	30	17	45	13	41	8	36	4	31			3	1
3 6	40	9	37	4	32	25 59	27	26 55	22	4	10	4	2
4 5	50	1	28	24 56	23	51	18	45	13	9	20	5	2
5 4	63 0	23 53	24 20	24 47	25 16	25 42	26 9	26 36	27 4	13	30	6	3
6 3	10	45	12	39	6	33	0	27	26 54	18	40	7	3
7 3	20	36	3	30	24 57	24	25 51	18	45	22	50	8	4
8 2	30	28	23 55	22	49	15	42	9	36			9	4
9 1	40	20	47	13	40	6	33	0	26				
	50	12	38	5	31	24 58	24	25 51	17				
	64 0	23 4	23 30	23 56	24 22	24 49	25 15	25 41	26 8				
0 9	10	22 55	21	48	13	40	6	32	25 58			1	0
1 8	20	47	13	39	5	31	24 57	23	49			2	1
2 7	30	39	5	30	23 56	22	48	14	39			3	1
3 6	40	30	22 56	22	47	13	39	4	30	4	10	4	2
4 5	50	22	48	13	39	4	30	24 55	21	8	20	5	2
5 4	65 0	22 14	22 39	23 4	23 30	23 55	24 21	24 46	25 11	13	30	6	3
6 3	10	5	31	22 56	21	46	11	37	2	17	40	7	3
7 3	20	21 57	22	47	12	37	2	27	24 52	21	50	8	3
8 2	30	49	14	38	3	28	23 53	18	43			9	4
9 1	40	40	5	30	22 54	19	44	9	34				
	50	32	21 56	21	46	10	35	23 59	24				
	66 0	21 23	21 48	22 12	22 37	23 1	23 25	23 50	24 14				
0 9	10	15	39	4	28	22 52	16	41	5			1	0
1 8	20	7	31	21 55	19	43	7	31	23 55			2	1
2 7	30	20 58	22	46	10	34	22 58	22	46			3	1
3 6	40	50	13	37	1	25	49	12	36	4	10	4	2
4 5	50	41	5	28	21 52	16	39	3	26	8	20	5	2
5 4	67 0	20 33	20 56	21 20	21 43	22 7	22 30	22 53	23 17	12	30	6	2
6 3	10	24	48	11	34	21 57	21	44	7	16	40	7	3
7 2	20	16	39	2	25	48	11	35	22 58	20	50	8	3
8 2	30	7	30	20 53	16	39	2	25	48			9	4
9 1	40	19 58	22	45	7	30	21 53	16	38				
	50	50	13	36	20 58	21	43	6	29				
	68 0	19 42	20 4	20 27	20 49	21 12	21 34	21 57	22 19				
0 9	10	33	19 55	18	40	2	25	47	9			1	0
1 8	20	25	47	9	31	20 53	15	38	0			2	1
2 7	30	16	38	0	22	44	6	28	21 50			3	1
3 6	40	7	29	19 51	13	35	20 57	18	40	4	10	4	1
4 6	50	18 59	21	42	4	26	47	9	30	7	20	5	2
5 5	69 0	18 50	19 12	19 33	19 55	20 16	20 38	20 59	21 21	11	30	6	2
6 4	10	42	3	24	46	7	28	49	11	14	40	7	3
7 3	20	33	18 54	15	37	19 58	19	40	1	18	50	8	3
8 2	30	24	46	6	27	48	9	30	20 51			9	3
9 1	40	16	38	18 57	18	39	0	21	42				
	50	6	28	47	8	29	19 50	10	31				

Auxiliary Arcs used in clearing the Lunar Distance.

Parts for Min. of ☽'s Alt. *Add*	☽'s App. Alt.	☽'s Horizontal Parallax.							
		54′	55′	56′	57′	58′	59′	60′	61′
		60°	60°	60°	60°	60°	60°	60°	60°
Alt.	Parts	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″
° ′	″	60 0	25 55	26 25	26 55	27 25	27 55	28 25	28 55	29 25
		10	58	28	58	28	58	28	58	28
0	0	20	26 0	30	27 0	30	28 1	31	29 1	31
1	0	30	3	33	3	33	4	34	4	34
2	1	40	6	36	6	36	6	36	6	37
3	1	50	8	38	8	38	9	39	9	40
4	1	61 0	26 11	26 41	27 11	27 41	28 12	28 42	29 12	29 43
5	1	10	14	44	14	44	15	45	15	46
6	2	20	16	46	16	46	17	48	18	49
7	2	30	19	49	19	49	20	51	21	52
8	2	40	21	51	22	52	23	53	23	54
9	2	50	24	54	24	54	25	56	26	57
		62 0	26 26	26 56	27 27	27 57	28 28	28 59	29 29	30 0
		10	29	59	30	28 0	31	29 2	32	3
0	0	20	31	27 1	32	2	33	4	35	5
1	0	30	34	4	35	5	36	7	38	8
2	1	40	36	6	37	8	39	10	40	11
3	1	50	39	9	40	10	41	12	43	13
4	1	63 0	26 41	27 11	27 42	28 13	28 44	29 15	29 46	30 16
5	1	10	43	14	45	16	47	18	49	19
6	2	20	46	16	47	18	49	20	51	21
7	2	30	48	19	50	21	52	23	54	24
8	2	40	50	21	52	23	54	26	57	27
9	2	50	53	24	55	26	57	28	59	29
		64 0	26 55	27 26	27 57	28 28	28 59	29 31	30 2	30 32
		10	57	28	59	31	29 2	34	5	35
0	0	20	27 0	31	28 2	33	4	36	7	37
1	0	30	2	33	4	36	7	39	10	40
2	0	40	4	35	6	38	9	41	12	43
3	1	50	7	38	9	41	12	44	15	45
4	1	65 0	27 9	27 40	28 11	28 43	29 14	29 46	30 17	30 48
5	1	10	11	42	13	45	16	48	20	51
6	1	20	13	45	16	48	19	51	22	53
7	2	30	16	47	18	50	21	53	25	56
8	2	40	18	49	20	52	23	55	27	58
9	2	50	20	52	23	55	26	58	30	31 1
		66 0	27 22	27 54	28 25	28 57	29 28	30 0	30 32	31 3
		10	24	56	27	59	30	2	34	6
0	0	20	26	58	29	29 1	33	5	37	8
1	0	30	29	28 1	32	4	35	7	39	11
2	0	40	31	3	34	6	37	9	41	13
3	1	50	33	5	36	8	40	12	44	16
4	1	67 0	27 35	28 7	28 38	29 10	29 42	30 14	30 46	31 18
5	1	10	37	9	40	12	44	16	48	20
6	1	20	39	11	42	14	46	18	51	23
7	2	30	41	13	45	17	49	21	53	25
8	2	40	43	15	47	19	51	23	55	27
9	2	50	45	17	49	21	53	25	58	30
		68 0	27 47	28 19	28 51	29 23	29 55	30 27	31 0	31 32
		10	49	21	53	25	57	29	2	34
0	0	20	51	23	55	27	59	31	4	36
1	0	30	53	25	57	30	30 2	34	7	39
2	0	40	55	27	59	32	4	36	9	41
3	1	50	57	29	29 1	34	6	38	11	43
4	1	69 0	27 59	28 31	29 3	29 36	30 8	30 40	31 13	31 45
5	1	10	28 1	33	5	38	10	42	15	47
6	1	20	3	35	7	40	12	44	17	49
7	1	30	5	37	9	42	14	46	19	52
8	2	40	6	39	11	44	16	48	21	54
9	2	50	8	41	13	46	18	50	23	56

Parts for Seconds of Parallax. *Add*			
Parts	Parallax.		Parts
″	″	″	″
		1	1
		2	1
5	10	3	2
10	20	4	2
15	30	5	3
20	40	6	3
25	50	7	4
		8	4
		9	5

Correction for Alt. of ☉ or ☿ *Add*

☉	
°	″
3	8
4	5
5	4
6	3
7	2
8	2
9	2
10	2
20	2
30	3
40	3
50	4
60	4
70	5
80	5
90	5

☿	
°	″
3	8
4	5
5	4
6	3
7	2
8	2
9	1
10	1
20	0
30	0
40	0
50	0
60	0
70	0
80	0
90	0

Correction of ☽'s Apparent Altitude

Parts for Min. of Alt. *Add*		☽'s App. Alt.	☽'s Horizontal Parallax. 54′	55′	56′	57′	58′	59′	60′	61′	Parts for Seconds of Parallax. *Add* Parts	Parallax.	Parts
Alt.	Parts	° ′	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	″	″	″
		70 0	17 58	18 19	18 39	19 0	19 21	19 41	20 2	20 22			
		10	50	10	30	18 51	11	32	19 52	12			
′	″	20	41	1	21	42	2	22	42	2			
0	9	30	32	17 52	12	32	18 52	13	33	19 53		1	0
1	8	40	24	43	3	23	43	3	23	43		2	1
2	7	50	15	35	17 54	14	34	18 53	13	33	3	3	1
3	6	71 0	17 6	17 26	17 45	18 5	18 24	18 44	19 3	19 23	6	4	1
4	6	10	16 57	17	36	17 56	15	34	18 54	13	10	5	2
5	5	20	48	8	27	46	6	25	44	3	13	6	2
6	4	30	41	16 59	18	37	17 56	15	34	18 53	16	7	2
7	3	40	31	50	9	28	47	6	24	43		8	3
8	2	50	22	41	0	19	37	17 56	15	33		9	3
9	1	72 0	16 14	16 32	16 51	17 9	17 28	17 46	18 5	18 23			
		10	5	23	42	0	18	37	17 55	14			
0	9	20	15 56	14	33	16 51	9	27	45	4		1	0
1	8	30	47	5	23	41	0	17	36	17 54		2	1
2	8	40	39	15 56	14	32	16 50	8	26	44	3	3	1
3	7	50	30	47	5	23	41	16 58	16	34	6	4	1
4	6	73 0	15 21	15 38	15 56	16 13	16 31	16 49	17 6	17 24	9	5	2
5	5	10	12	29	47	4	22	39	16 56	14	12	6	2
6	4	20	3	20	38	15 55	12	29	46	4	15	7	2
7	3	30	14 54	11	28	45	3	20	37	16 54		8	2
8	2	40	45	2	19	36	15 53	10	27	44		9	3
9	1	50	37	14 53	10	27	43	0	17	34			
		74 0	14 28	14 45	15 1	15 17	15 34	15 50	16 7	16 24			
0	9	10	19	35	14 52	8	24	41	15 57	13			
1	8	20	10	26	42	14 59	15	31	47	3		1	0
2	8	30	1	17	33	49	5	21	37	15 53		2	1
3	7	40	13 52	8	24	40	14 56	11	27	43	3	3	1
4	6	50	43	13 59	15	30	46	2	17	33	5	4	1
5	5	75 0	13 34	13 50	14 5	14 21	14 36	14 52	15 7	15 23	8	5	1
6	4	10	25	41	13 56	11	27	42	14 58	13	10	6	2
7	3	20	16	32	47	2	17	32	48	3	13	7	2
8	2	30	7	23	38	13 53	8	23	38	14 53		8	2
9	1	40	12 59	13	28	43	13 58	13	28	43		9	2
		50	50	4	19	34	48	3	18	32			
		76 0	12 41	12 55	13 10	13 24	13 39	13 53	14 8	14 22			
0	10	10	32	46	0	15	29	43	13 58	12			
1	9	20	23	37	12 51	5	19	34	48	2		1	0
2	8	30	14	28	42	12 56	10	24	38	13 52		2	0
3	7	40	5	19	32	46	0	14	28	42	2	3	1
4	6	50	11 56	9	23	37	12 50	4	18	31	4	4	1
5	5	77 0	11 47	12 0	12 14	12 27	12 41	12 54	13 8	13 21	7	5	1
6	4	10	38	11 51	4	18	31	44	12 58	11	9	6	1
7	3	20	29	42	11 55	8	21	34	48	1	11	7	2
8	2	30	20	33	46	11 59	12	25	38	12 51		8	2
9	1	40	11	23	36	49	2	15	28	40		9	2
		50	2	14	27	40	11 52	5	17	30			
		78 0	10 53	11 5	11 17	11 30	11 42	11 55	12 7	12 20			
0	10	10	43	10 56	8	20	33	45	11 56	10			
1	9	20	34	47	10 58	11	23	35	47	11 59		1	0
2	8	30	25	37	49	1	13	25	37	49		2	0
3	7	40	16	28	40	10 52	3	15	27	39	2	3	1
4	6	50	7	19	30	42	10 54	5	17	29	4	4	1
5	5	79 0	9 58	10 10	10 21	10 32	10 44	10 55	11 7	11 18	6	5	1
6	4	10	49	0	12	23	34	45	10 57	8	8	6	1
7	3	20	40	9 51	2	13	24	35	47	10 58	10	7	1
8	2	30	31	42	9 53	4	15	26	37	48		8	2
9	1	40	22	33	43	9 54	5	16	26	37		9	2
		50	13	23	34	44	9 55	6	16	27			

Auxiliary Arcs used in clearing the Lunar Distance.

Parts for Min. of ☽'s Alt. *Add*	☽'s App. Alt.	☽'s Horizontal Parallax. 54′	55′	56′	57′	58′	59′	60′	61′
		60°	60°	60°	60°	60°	60°	60°	60°
Alt. / Parts	° ′	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″
	70 0	28 10	28 48	29 15	29 48	30 20	30 52	31 25	31 58
	10	12	45	17	50	22	54	27	32 0
0 0	20	14	47	19	52	24	56	29	2
1 0	30	16	49	21	54	26	58	31	4
2 0	40	17	50	22	55	27	31 0	33	6
3 1	50	19	52	24	57	29	2	35	8
4 1	71 0	28 21	28 54	29 26	29 59	30 31	31 4	31 37	32 10
5 1	10	23	56	28	30 1	33	6	39	12
6 1	20	24	57	30	3	35	8	41	14
7 1	30	26	59	32	5	37	10	43	16
8 2	40	28	29 1	33	6	38	11	44	17
9 2	50	29	2	35	8	40	13	46	19
	72 0	28 31	29 4	29 37	30 10	30 42	31 15	31 48	32 21
	10	33	6	39	12	44	17	50	23
0 0	20	34	7	40	13	46	19	52	25
1 0	30	36	9	42	15	48	21	54	27
2 0	40	38	11	44	17	49	22	55	28
3 1	50	39	12	45	18	51	24	57	30
4 1	73 0	28 41	29 14	29 47	30 20	30 53	31 26	31 59	32 32
5 1	10	43	16	49	22	55	28	32 1	34
6 1	20	44	17	50	23	56	29	2	35
7 1	30	46	19	52	25	58	31	4	37
8 1	40	47	20	53	27	31 0	33	6	39
9 2	50	49	22	55	28	1	34	7	40
	74 0	28 50	29 23	29 56	30 30	31 3	31 36	32 9	32 42
	10	52	25	58	32	5	38	11	44
0 0	20	53	26	59	33	6	39	12	45
1 0	30	55	28	30 1	35	8	41	14	47
2 0	40	56	29	2	36	9	42	16	49
3 0	50	58	31	4	38	11	44	17	50
4 1	75 0	28 59	29 32	30 5	30 39	31 12	31 45	32 19	32 52
5 1	10	29 0	33	6	40	14	47	21	54
6 1	20	2	35	8	42	15	48	22	55
7 1	30	3	36	9	43	17	50	24	57
8 1	40	4	37	10	44	18	51	25	58
9 1	50	6	39	12	46	20	53	27	33 0
	76 0	29 7	29 40	30 13	30 47	31 21	31 54	32 28	33 1
	10	8	41	14	48	22	55	29	2
0 0	20	9	43	16	50	24	57	31	4
1 0	30	11	44	17	51	25	58	32	5
2 0	40	12	45	18	52	26	59	33	6
3 0	50	13	47	20	54	28	32 1	35	8
4 0	77 0	29 14	29 48	30 21	30 55	31 29	32 2	32 36	33 9
5 1	10	15	49	22	56	30	3	37	10
6 1	20	16	50	23	57	31	5	38	12
7 1	30	18	52	25	59	33	6	40	13
8 1	40	19	53	26	31 0	34	7	41	14
9 1	50	20	54	27	1	35	9	42	16
	78 0	29 21	29 55	30 28	31 2	31 36	32 10	32 43	33 17
	10	22	56	29	3	37	11	44	18
0 0	20	23	57	30	4	38	12	45	19
1 0	30	24	58	32	6	40	14	47	21
2 0	40	25	59	33	7	41	15	48	22
3 0	50	26	30 0	34	8	42	16	49	23
4 0	79 0	29 27	30 1	30 35	31 9	31 43	32 17	32 50	33 24
5 1	10	28	2	36	10	44	18	51	25
6 1	20	29	3	37	11	45	19	52	26
7 1	30	30	4	38	12	46	20	54	28
8 1	40	31	5	39	13	47	21	55	29
9 1	50	32	6	40	14	48	22	56	30

Parts for Seconds of Parallax. *Add*			
Parts	Parallax.		Parts
″	″	″	″
		1	1
		2	1
5	10	3	2
11	20	4	2
16	30	5	3
22	40	6	3
27	50	7	4
		8	4
		9	5
		1	1
		2	1
6	10	3	2
11	20	4	2
17	30	5	3
22	40	6	3
28	50	7	4
		8	4
		9	5
		1	1
		2	1
6	10	3	2
11	20	4	2
17	30	5	3
22	40	6	3
28	50	7	4
		8	4
		9	5
		1	1
		2	1
6	10	3	2
11	20	4	2
17	30	5	3
22	40	6	3
28	50	7	4
		8	4
		9	5
		1	1
		2	1
6	10	3	2
11	20	4	2
17	30	5	3
22	40	6	3
28	50	7	4
		8	4
		9	5

Correction for Alt. of ☉ or ☿ *Add* ☉

°	″
3	8
4	5
5	4
6	3
7	2
8	2
9	2
10	2
20	2
30	3
40	3
50	4
60	4
70	5
80	5
90	5

☿

°	″
3	8
4	5
5	4
6	3
7	2
8	2
9	1
10	1
20	0
30	0
40	0
50	0
60	0
70	0
80	0
90	0

Correction of ☽'s Apparent Altitude.

Parts for Min. of Alt. *Add*	☽'s App. Alt.	☽'s Horizontal Parallax. 54′	55′	56′	57′	58′	59′	60′	61′
Alt. / Parts	° ′	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″
	80 0	9 3	9 13	9 23	9 34	9 44	9 55	10 5	10 15
	10	8 53	4	14	24	34	45	9 55	5
′ ″	20	44	8 54	5	15	26	35	45	9 55
0 10	30	35	45	8 55	5	15	25	35	45
1 9	40	26	36	46	8 55	5	15	24	34
2 8	50	17	27	36	46	8 55	5	14	24
3 7	81 0	8 8	8 17	8 27	8 36	8 46	8 55	9 4	9 14
4 6	10	7 59	8	17	26	36	45	8 54	3
5 5	20	50	7 59	8	17	26	35	44	8 53
6 4	30	40	49	7 58	7	16	25	34	42
7 3	40	31	40	49	7 57	6	15	23	32
8 2	50	22	31	39	48	7 56	5	13	22
9 1	82 0	7 13	7 21	7 30	7 38	7 46	7 55	8 3	8 11
	10	4	12	20	28	36	45	7 53	1
	20	6 55	3	11	19	27	35	43	7 51
0 10	30	45	6 53	1	9	17	25	32	40
1 9	40	36	44	6 52	6 59	7	15	22	30
2 8	50	27	35	42	50	6 57	4	12	19
3 7	83 0	6 18	6 25	6 32	6 40	6 47	6 54	7 2	7 9
4 6	10	9	16	23	30	37	44	6 52	6 59
5 5	20	5 59	6	13	20	27	34	41	48
6 4	30	50	5 57	4	11	17	24	31	38
7 3	40	41	48	5 54	1	8	14	21	27
8 2	50	32	38	45	5 51	5 58	4	11	17
9 1	84 0	5 23	5 29	5 35	5 42	5 48	5 54	6 0	6 7
	10	13	20	26	32	38	44	5 50	5 56
	20	4	10	16	22	28	34	40	46
0 10	30	4 55	1	7	12	18	24	30	35
1 9	40	46	4 51	4 57	3	8	14	19	25
2 8	50	37	42	47	4 53	4 58	4	9	14
3 7	85 0	4 27	4 33	4 38	4 43	4 48	4 54	4 59	5 4
4 6	10	18	23	28	33	38	43	48	4 54
5 5	20	9	14	19	24	28	33	38	43
6 4	30	0	4	9	14	19	23	28	33
7 3	40	3 50	3 55	0	4	9	13	18	22
8 2	50	41	46	3 50	3 54	3 59	3	7	12
9 1	86 0	3 32	3 36	3 40	3 45	3 49	3 53	3 57	4 1
	10	23	27	31	35	39	43	47	3 51
	20	14	17	21	25	29	33	37	40
0 10	30	4	8	12	15	19	23	26	30
1 9	40	2 55	2 59	2	6	9	13	16	20
2 8	50	46	49	2 52	2 56	2 59	2	6	9
3 7	87 0	2 36	2 40	2 43	2 46	2 49	2 52	2 55	2 59
4 6	10	27	30	33	36	39	42	45	48
5 5	20	18	21	24	26	29	32	35	38
6 4	30	9	11	14	17	19	22	25	27
7 3	40	0	2	4	7	9	12	14	17
8 2	50	1 50	1 53	1 55	1 57	1 59	2	4	6
9 1	88 0	1 41	1 43	1 45	1 47	1 49	1 52	1 54	1 56
	10	32	34	36	38	40	41	43	45
	20	23	24	26	28	30	31	33	35
0 10	30	13	15	16	18	20	21	23	24
1 9	40	4	5	7	8	10	11	12	14
2 8	50	0 55	0 56	0 57	0 58	0	1	2	3
3 7	89 0	0 46	0 47	0 48	0 49	0 50	0 51	0 52	0 53
4 6	10	36	37	38	39	40	41	42	42
5 5	20	27	28	28	29	30	31	31	32
6 4	30	19	19	19	19	20	20	21	21
7 3	40	10	10	10	10	10	10	11	11
8 2	50	0	0	0	0	0	0	0	0
9 1									

Parts for Seconds of Parallax. *Add*			
Parts	Parallax.		Parts
″	″	″	″
		1	0
		2	0
2	10	3	0
3	20	4	1
5	30	5	1
6	40	6	1
8	50	7	1
		8	1
		9	1
		1	0
		2	0
1	10	3	0
2	20	4	0
4	30	5	1
5	40	6	1
6	50	7	1
		8	1
		9	1
		1	0
		2	0
1	10	3	0
2	20	4	0
3	30	5	0
4	40	6	1
5	50	7	1
		8	1
		9	1
		1	0
		2	0
1	10	3	0
1	20	4	0
2	30	5	0
2	40	6	0
3	50	7	0
		8	0
		9	1
		1	0
		2	0
		3	0
0	10	4	0
0	20	5	0
1	30	6	0
1	40	7	0
1	50	8	0
		9	0

Auxiliary Arcs used in clearing the Lunar Distance.

Parts for Min. of ☽'s Alt. *Add*	☽'s App. Alt.	☽'s Horizontal Parallax. 54′	55′	56′	57′	58′	59′	60′	61′
		60°	60°	60°	60°	60°	60°	60°	60°
Alt. / Parts	° ′	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″	′ ″
	80 0	29 33	30 7	30 41	31 15	31 49	32 23	32 57	33 31
	10	34	8	42	16	50	24	58	32
′ ″	20	35	9	43	17	51	25	59	33
0 0	30	36	10	44	18	52	26	33 0	34
1 0	40	36	10	44	18	52	26	1	35
2 0	50	37	11	45	19	53	27	2	36
3 0	81 0	29 38	30 12	30 46	31 20	31 54	32 28	33 3	33 37
4 0	10	39	13	47	21	55	29	4	38
5 0	20	40	14	48	22	56	30	5	39
6 0	30	41	15	49	23	57	31	6	40
7 1	40	41	15	49	23	57	31	6	40
8 1	50	42	16	50	24	58	32	7	41
9 1	82 0	29 43	30 17	30 51	31 25	31 59	32 33	33 8	33 42
	10	44	18	52	26	32 0	34	9	43
0 0	20	44	18	52	27	1	35	9	43
1 0	30	45	19	53	28	2	36	10	44
2 0	40	46	20	54	28	2	36	11	45
3 0	50	46	20	54	29	3	37	11	45
4 0	83 0	29 47	30 21	30 55	31 30	32 4	32 38	33 12	33 46
5 0	10	48	22	56	31	5	39	13	47
6 0	20	48	22	56	31	5	39	13	47
7 0	30	49	23	57	32	6	40	14	48
8 1	40	49	24	58	33	7	41	15	49
9 1	50	50	24	58	33	7	41	15	49
	84 0	29 50	30 25	30 59	31 34	32 8	32 42	33 16	33 50
	10	51	26	31 0	35	9	43	17	51
0 0	20	51	26	0	35	9	43	17	51
1 0	30	52	27	1	36	10	44	18	52
2 0	40	52	27	1	36	10	44	18	52
3 0	50	53	28	2	37	11	45	19	53
4 0	85 0	29 53	30 28	31 2	31 37	32 11	32 45	33 19	33 54
5 0	10	54	29	3	37	12	46	20	55
6 0	20	54	29	3	38	12	46	20	55
7 0	30	55	30	4	38	13	47	21	56
8 0	40	55	30	4	38	13	47	21	56
9 0	50	56	31	5	39	14	48	22	57
	86 0	29 56	30 31	31 5	31 39	32 14	32 48	33 22	33 57
0 0	10	56	31	5	39	14	48	22	57
1 0	20	57	32	6	40	15	49	23	58
2 0	30	57	32	6	40	15	49	23	58
3 0	40	57	32	6	40	15	49	23	58
4 0	50	58	33	7	41	16	50	24	59
5 0	87 0	29 58	30 33	31 7	31 41	32 16	32 50	33 24	33 59
6 0	10	58	33	7	41	16	50	24	59
7 0	20	58	33	7	42	16	51	25	34 0
8 0	30	59	34	8	42	17	51	25	0
9 0	40	59	34	8	42	17	51	25	0
	50	59	34	8	43	17	52	26	1
	88 0	29 59	30 34	31 8	31 43	32 17	32 52	33 26	34 1
0 0	10	59	34	8	43	17	52	26	1
1 0	20	59	34	8	43	17	52	26	1
2 0	30	30 0	35	9	44	18	53	27	1
3 0	40	0	35	9	44	18	53	27	1
4 0	50	0	35	9	44	18	53	27	1
5 0	89 0	30 0	30 35	31 9	31 44	32 19	32 53	33 27	34 1
6 0	10	0	35	9	44	19	53	27	1
7 0	20	0	35	9	44	19	53	27	1
8 0	30	1	35	10	44	19	53	27	2
9 0	40	1	35	10	44	19	53	27	2
	50	1	35	10	44	19	53	27	2

Parts for Seconds of Parallax. *Add*

Parts	Parallax.		Parts
″	″	″	″
		1	1
		2	1
6	10	3	2
11	20	4	2
17	30	5	3
23	40	6	3
29	50	7	4
		8	5
		9	5

Correction for Alt. of ☉ or ☿ *Add*

☉	
°	′
3	8
4	5
5	4
6	3
7	2
8	2
9	2
10	2
20	2
30	3
40	3
50	4
60	4
70	5
80	5
90	5

☿

°	′
3	8
4	5
5	4
6	3
7	2
8	2
9	1
10	1
20	0
30	0
40	0
50	0
60	0
70	0
80	0
90	0

TABLE XXVI.

Parallax of the Planets in Altitude.

App. Alt.	Planet's Horizontal Parallax.															
	″ 1	″ 3	″ 5	″ 7	″ 9	″ 11	″ 13	″ 15	″ 17	″ 19	″ 21	″ 23	″ 25	″ 27	″ 29	″ 31
°	″	″	″	″	″	″	″	″	″	″	″	″	″	″	″	″
0	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31
10	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	30
20	1	3	5	7	9	10	12	14	16	18	20	22	24	25	27	29
25	1	3	5	6	8	10	12	14	15	17	19	21	23	24	26	28
30	1	3	4	6	8	10	11	13	15	16	18	20	22	23	25	27
33	1	2	4	6	8	9	11	13	14	16	18	19	21	23	24	26
36	1	2	4	6	7	9	11	12	14	15	17	19	20	22	23	25
39	1	2	4	5	7	9	10	12	13	15	16	18	19	21	23	24
42	1	2	4	5	7	8	10	11	13	14	16	17	19	20	22	23
45	1	2	4	5	6	8	9	11	12	13	15	16	18	19	21	22
48	1	2	3	5	6	7	9	10	11	13	14	15	17	18	19	21
51	1	2	3	4	6	7	8	9	11	12	13	14	16	17	18	20
54	1	2	3	4	5	6	8	9	10	11	12	14	15	16	17	18
57	1	2	3	4	5	6	7	8	9	10	11	12	14	15	16	17
60	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
63	0	1	2	3	4	5	6	7	8	9	10	10	11	12	13	14
66	0	1	2	3	4	4	5	6	7	8	9	9	10	11	12	13
69	0	1	2	3	3	4	5	5	6	7	8	8	9	10	10	11
72	0	1	2	2	3	3	4	5	5	6	6	7	8	8	9	10
75	0	1	1	2	2	3	3	4	4	5	5	6	6	7	8	8
78	0	1	1	1	2	2	3	3	4	4	4	5	5	6	6	6
81	0	0	1	1	1	2	2	2	3	3	3	4	4	4	5	5
84	0	0	1	1	1	1	1	2	2	2	2	2	3	3	3	3
87	0	0	0	0	0	1	1	1	1	1	1	1	1	1	2	2
90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TABLE XXVII.

Corrections to be added to the Arcs from Table XXV. in *clearing the Distance* between ☽ and a Planet.

App. Alt.	Planet's Horizontal Parallax.															
	″ 1	″ 3	″ 5	″ 7	″ 9	″ 11	″ 13	″ 15	″ 17	″ 19	″ 21	″ 23	″ 25	″ 27	″ 29	″ 31
°	″	″	″	″	″	″	″	″	″	″	″	″	″	″	″	″
3	8	8	8	8	8	8	8	8	9	9	9	9	9	9	9	9
4	5	5	5	5	5	5	6	6	6	6	6	6	6	6	6	6
5	4	4	4	4	4	5	5	5	5	5	5	5	5	5	5	6
6	3	3	3	3	4	4	4	4	4	4	4	4	4	5	5	5
7	2	2	2	3	3	3	3	3	3	3	4	4	4	4	4	4
8	2	2	2	3	3	3	3	3	3	3	4	4	4	4	4	4
9	1	1	1	2	2	2	2	2	3	3	3	3	3	4	4	4
10	0	1	1	2	2	2	2	2	3	3	3	3	3	4	4	4
15	0	1	1	1	1	2	2	2	3	3	3	4	4	5	5	5
20	0	1	1	1	2	2	2	3	3	4	4	4	5	5	6	6
25	0	1	1	2	2	2	3	3	4	4	4	5	6	6	7	7
30	1	1	1	2	3	3	4	4	5	6	6	7	7	8	9	9
40	1	1	2	2	3	4	5	5	6	7	8	8	9	10	11	11
50	1	1	3	3	4	5	6	6	8	9	9	10	11	12	13	14
60	1	1	3	3	4	5	6	7	8	9	10	11	12	13	14	16
70	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
80	1	2	3	4	5	6	7	8	9	10	12	13	14	15	16	17
90	1	2	3	4	5	6	7	8	9	10	12	13	14	15	16	17

TABLE XXVIII.

Decimal Versed and Suversed Sines.

′ / ″ Vers.	0° Vers.	Parts for ″	0° Suvers.	1° Vers.	Parts for ″	1° Suvers.	2° Vers.	Parts for ″	2° Suvers.	3° Vers.	Parts for ″	3° Suvers.	″ Suv.
0	00000	0	00000	00152	0	99848	00609	0	99391	01370	0	98630	60
1	00000	0	00000	00157	0	99843	00619	0	99381	01386	0	98614	59
2	00000	0	00000	00163	0	99837	00630	0	99370	01401	1	98599	58
3	00000	0	00000	00168	0	99832	00640	1	99360	01416	1	98584	57
4	00001	0	99999	00173	0	99827	00650	1	99350	01432	1	98568	56
5	00001	0	99999	00179	0	99821	00661	1	99339	01448	1	98552	55
6	00001	0	99999	00184	1	99816	00672	1	99328	01463	2	98537	54
7	00002	0	99998	00190	1	99810	00682	1	99318	01479	2	98521	53
8	00003	1	99997	00196	1	99804	00693	1	99307	01495	2	98505	52
9	00003	1	99997	00201	1	99799	00704	2	99296	01511	2	98489	51
10	00004	1	99996	00207	1	99793	00715	2	99285	01527	3	98473	50
11	00005	1	99995	00213	1	99787	00726	2	99274	01543	3	98457	49
12	00006	1	99994	00219	1	99781	00737	2	99263	01559	3	98441	48
13	00007	1	99993	00226	1	99774	00748	2	99252	01575	4	98425	47
14	00008	1	99992	00232	1	99768	00760	3	99240	01592	4	98408	46
15	00009	1	99991	00238	2	99762	00771	3	99229	01608	4	98392	45
16	00011	1	99989	00244	2	99756	00782	3	99218	01625	4	98375	44
17	00012	1	99988	00251	2	99749	00794	3	99206	01641	4	98359	43
18	00014	1	99986	00257	2	99743	00806	3	99194	01658	5	98342	42
19	00015	1	99985	00264	2	99736	00817	4	99183	01675	5	98325	41
20	00017	1	99983	00271	2	99729	00829	4	99171	01692	5	98308	40
21	00019	1	99981	00278	2	99722	00841	4	99159	01709	6	98291	39
22	00020	2	99980	00284	2	99716	00853	4	99147	01726	6	98274	38
23	00022	2	99978	00291	2	99709	00865	4	99135	01743	6	98257	37
24	00024	2	99976	00299	3	99701	00877	5	99123	01760	7	98240	36
25	00026	2	99974	00306	3	99694	00889	5	99111	01777	7	98223	35
26	00029	2	99971	00313	3	99687	00902	5	99098	01795	7	98205	34
27	00031	2	99969	00320	3	99680	00914	5	99086	01812	8	98188	33
28	00033	2	99967	00328	3	99672	00927	5	99073	01830	8	98170	32
29	00036	2	99964	00335	3	99665	00939	6	99061	01847	8	98153	31
30	00038	2	99962	00343	3	99657	00952	6	99048	01865	9	98135	30
31	00041	2	99959	00350	4	99650	00964	7	99036	01883	9	98117	29
32	00043	2	99957	00358	4	99642	00977	7	99023	01901	10	98099	28
33	00046	2	99954	00366	4	99634	00990	7	99010	01919	10	98081	27
34	00049	2	99951	00374	4	99626	01003	8	98997	01937	11	98063	26
35	00052	2	99948	00382	4	99618	01016	8	98984	01955	11	98045	25
36	00055	2	99945	00390	5	99610	01029	8	98971	01973	11	98027	24
37	00058	2	99942	00398	5	99602	01043	9	98957	01992	12	98008	23
38	00061	2	99939	00406	5	99594	01056	9	98944	02010	12	97990	22
39	00064	2	99936	00415	5	99585	01069	9	98931	02028	12	97972	21
40	00068	2	99932	00423	6	99577	01083	9	98917	02047	13	97953	20
41	00071	2	99929	00432	6	99568	01096	10	98904	02066	13	97934	19
42	00075	2	99925	00440	6	99560	01110	10	98890	02084	13	97916	18
43	00078	2	99922	00449	6	99551	01124	10	98876	02103	14	97897	17
44	00082	2	99918	00458	6	99542	01138	10	98862	02122	14	97878	16
45	00086	3	99914	00466	6	99534	01152	11	98848	02141	14	97859	15
46	00089	3	99911	00475	6	99525	01166	11	98834	02160	15	97840	14
47	00093	3	99907	00484	7	99516	01180	11	98820	02179	15	97821	13
48	00097	3	99903	00493	7	99507	01194	11	98806	02198	15	97802	12
49	00102	3	99898	00503	7	99497	01208	11	98792	02218	16	97782	11
50	00106	3	99894	00512	7	99488	01222	12	98778	02237	16	97763	10
51	00110	3	99890	00521	7	99479	01237	12	98763	02257	16	97743	9
52	00114	3	99886	00531	7	99469	01251	12	98749	02276	16	97724	8
53	00119	3	99881	00540	7	99460	01266	12	98734	02296	17	97704	7
54	00123	3	99877	00550	8	99450	01281	13	98719	02316	17	97684	6
55	00128	3	99872	00559	8	99441	01295	13	98705	02335	17	97665	5
56	00133	3	99867	00569	8	99431	01310	13	98690	02355	18	97645	4
57	00137	3	99863	00579	8	99421	01325	14	98675	02375	18	97625	3
58	00142	3	99858	00589	8	99411	01340	14	98660	02395	18	97605	2
59	00147	3	99853	00599	8	99401	01355	14	98645	02416	19	97584	1
60	00152	4	99848	00609	9	99391	01370	14	98630	02436	19	97564	0
′ / ″ Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	′ / ″ Suv.
	179°			178°			177°			176°			

TABLE XXVIII.

Decimal Versed and Suversed Sines.

′ [′ Vers.]	4°			5°			6°			7°			[″ Suv.]
	Vers.	Parts for ″	Suvers.	Vers.	Parts for ″	Suvers.	Vers.	Parts for ″	Suvers.	Vers.	Parts for ″	Suvers.	
0	02436	0	97564	03805	0	96195	05478	0	94522	07454	0	92546	60
1	02456	0	97544	03831	0	96169	05509	1	94491	07489	1	92511	59
2	02477	1	97523	03856	1	96144	05539	1	94461	07525	1	92475	58
3	02497	1	97503	03882	1	96118	05570	2	94430	07561	2	92439	57
4	02518	1	97482	03907	2	96093	05600	2	94400	07596	2	92404	56
5	02538	2	97462	03933	2	96067	05631	3	94369	07632	3	92368	55
6	02559	2	97441	03959	3	96041	05662	3	94338	07668	4	92332	54
7	02580	3	97420	03985	3	96015	05693	4	94307	07704	4	92296	53
8	02601	3	97399	04011	3	95989	05724	4	94276	07740	5	92260	52
9	02622	3	97378	04037	4	95963	05755	5	94245	07776	6	92224	51
10	02643	4	97357	04063	4	95937	05786	5	94214	07813	6	92187	50
11	02664	4	97336	04089	5	95911	05818	6	94182	07849	7	92151	49
12	02685	4	97315	04116	5	95884	05849	6	94151	07885	7	92115	48
13	02707	5	97293	04142	6	95858	05880	7	94120	07922	8	92078	47
14	02728	5	97272	04168	6	95832	05912	7	94088	07958	9	92042	46
15	02750	5	97250	04195	7	95805	05944	8	94056	07995	9	92005	45
16	02771	6	97229	04222	7	95778	05975	8	94025	08032	10	91968	44
17	02793	6	97207	04248	7	95752	06007	9	93993	08069	10	91931	43
18	02815	6	97185	04275	8	95725	06039	9	93961	08106	11	91894	42
19	02837	7	97163	04302	8	95698	06071	10	93929	08143	12	91857	41
20	02859	7	97141	04329	9	95671	06103	10	93897	08180	12	91820	40
21	02881	7	97119	04356	9	95644	06135	11	93865	08217	13	91783	39
22	02903	8	97097	04383	10	95617	06167	11	93833	08254	13	91746	38
23	02925	8	97075	04411	10	95589	06200	12	93800	08291	14	91709	37
24	02947	8	97053	04438	11	95562	06232	13	93768	08329	15	91671	36
25	02970	9	97030	04465	11	95535	06264	13	93736	08366	15	91634	35
26	02992	9	97008	04493	11	95507	06297	14	93703	08404	16	91596	34
27	03015	10	96985	04520	12	95480	06330	14	93670	08442	17	91558	33
28	03037	10	96963	04548	12	95452	06362	15	93638	08479	17	91521	32
29	03060	10	96940	04576	13	95424	06395	15	93605	08517	18	91483	31
30	03083	11	96917	04604	13	95396	06428	16	93572	08555	19	91445	30
31	03105	12	96895	04632	15	95368	06461	17	93539	08593	20	91407	29
32	03128	13	96872	04660	15	95340	06494	18	93506	08631	21	91369	28
33	03151	13	96849	04688	16	95312	06527	19	93473	08669	22	91331	27
34	03175	14	96825	04716	16	95284	06560	19	93440	08708	22	91292	26
35	03198	14	96802	04744	17	95256	06594	20	93406	08746	23	91254	25
36	03221	15	96779	04773	18	95227	06627	21	93373	08784	24	91216	24
37	03244	15	96756	04801	18	95199	06661	21	93339	08823	24	91177	23
38	03268	16	96732	04829	19	95171	06694	22	93306	08862	25	91138	22
39	03291	16	96709	04858	19	95142	06728	22	93272	08900	26	91100	21
40	03315	16	96685	04887	20	95113	06762	23	93238	08939	26	91061	20
41	03339	17	96661	04916	20	95084	06795	23	93205	08978	27	91022	19
42	03363	17	96637	04944	21	95056	06829	24	93171	09017	28	90983	18
43	03386	17	96614	04973	21	95027	06863	24	93137	09056	28	90944	17
44	03410	18	96590	05002	21	94998	06897	25	93103	09095	29	90905	16
45	03434	18	96566	05031	22	94969	06931	26	93069	09134	30	90866	15
46	03459	19	96541	05061	22	94939	06966	26	93034	09173	30	90827	14
47	03483	19	96517	05090	23	94910	07000	27	93000	09213	31	90787	13
48	03507	20	96493	05119	23	94881	07034	28	92966	09252	32	90748	12
49	03531	20	96469	05149	24	94851	07069	28	92931	09292	32	90708	11
50	03556	20	96444	05178	25	94822	07103	29	92897	09331	33	90669	10
51	03580	21	96420	05208	25	94792	07138	29	92862	09371	34	90629	9
52	03605	21	96395	05237	26	94763	07173	30	92827	09411	34	90589	8
53	03630	22	96370	05267	26	94733	07208	30	92792	09451	35	90549	7
54	03655	22	96345	05297	27	94703	07243	31	92757	09490	36	90510	6
55	03680	22	96320	05327	27	94673	07278	31	92722	09531	36	90469	5
56	03705	23	96295	05357	28	94643	07313	32	92687	09571	37	90429	4
57	03730	23	96270	05387	28	94613	07348	32	92652	09611	38	90389	3
58	03755	24	96245	05417	29	94583	07383	33	92617	09651	38	90349	2
59	03780	24	96220	05448	29	94552	07418	34	92582	09691	39	90309	1
60	03805	24	96195	05478	29	94522	07454	34	92546	09732	39	90268	0
[″ Vers.]	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	[′ ″ Suv.]
	175°			174°			173°			172°			

TABLE XXVIII.

Decimal Versed and Suversed Sines.

′ / ″ Vers.	8°			9°			10°			11°			″ Suv. ′
	Vers.	Parts for ″	Suvers.	Vers.	Parts for ″	Suvers.	Vers.	Parts for ″	Suvers.	Vers.	Parts for ″	Suvers.	
0	09732	0	90268	12312	0	87688	15192	0	84808	18373	0	81627	60
1	09772	1	90228	12357	1	87643	15243	1	84757	18428	1	81572	59
2	09813	1	90187	12403	1	87597	15293	2	84707	18484	2	81516	58
3	09854	2	90146	12449	2	87551	15344	3	84656	18540	3	81460	57
4	09894	3	90106	12494	3	87506	15395	3	84605	18595	4	81405	56
5	09935	3	90065	12540	4	87460	15446	4	84554	18651	5	81349	55
6	09976	4	90024	12586	5	87414	15497	5	84503	18707	6	81293	54
7	10017	5	89983	12632	6	87368	15548	6	84452	18763	7	81237	53
8	10058	6	89942	12678	7	87322	15599	7	84401	18819	7	81181	52
9	10100	6	89900	12725	8	87275	15650	8	84350	18876	8	81124	51
10	10141	7	89859	12771	8	87229	15701	9	84299	18932	9	81068	50
11	10182	8	89818	12817	9	87183	15753	9	84247	18988	10	81012	49
12	10224	8	89776	12864	10	87136	15804	10	84196	19045	11	80955	48
13	10265	9	89735	12910	11	87090	15856	11	84144	19101	12	80899	47
14	10307	10	89693	12957	12	87043	15908	12	84092	19158	13	80842	46
15	10349	10	89651	13004	12	86996	15959	13	84041	19215	14	80785	45
16	10390	11	89610	13050	13	86950	16011	14	83989	19271	15	80729	44
17	10432	12	89568	13097	13	86903	16063	15	83937	19328	16	80672	43
18	10474	12	89526	13144	14	86856	16115	16	83885	19385	17	80615	42
19	10516	13	89484	13191	15	86809	16167	16	83833	19442	18	80558	41
20	10558	14	89442	13238	15	86762	16219	17	83781	19499	19	80501	40
21	10601	14	89399	13286	16	86714	16271	18	83729	19557	20	80443	39
22	10643	15	89357	13333	17	86667	16324	19	83676	19614	21	80386	38
23	10685	16	89315	13380	18	86620	16376	20	83624	19671	22	80329	37
24	10728	17	89272	13428	19	86572	16428	21	83572	19729	23	80271	36
25	10770	17	89230	13475	19	86525	16481	22	83519	19786	24	80214	35
26	10813	18	89187	13523	20	86477	16534	22	83466	19844	25	80156	34
27	10855	19	89145	13571	21	86429	16586	23	83414	19902	26	80098	33
28	10898	19	89102	13618	22	86382	16639	24	83361	19959	27	80041	32
29	10941	20	89059	13666	23	86334	16692	25	83308	20017	28	79983	31
30	10984	21	89016	13714	24	86286	16745	26	83255	20075	29	79925	30
31	11027	22	88973	13762	25	86238	16798	27	83202	20133	30	79867	29
32	11070	23	88930	13811	26	86189	16851	28	83149	20191	31	79809	28
33	11113	24	88887	13859	27	86141	16904	29	83096	20250	32	79750	27
34	11157	25	88843	13907	28	86093	16958	30	83042	20308	33	79692	26
35	11200	26	88800	13955	29	86045	17011	31	82989	20366	34	79634	25
36	11244	26	88756	14004	30	85996	17065	32	82935	20425	35	79575	24
37	11287	27	88713	14052	31	85948	17118	33	82882	20483	36	79517	23
38	11331	28	88669	14101	32	85899	17172	34	82828	20542	37	79458	22
39	11374	28	88626	14150	33	85850	17226	35	82774	20601	38	79399	21
40	11418	29	88582	14199	33	85801	17279	36	82721	20659	39	79341	20
41	11462	30	88538	14248	34	85752	17333	37	82667	20718	40	79282	19
42	11506	31	88494	14296	35	85704	17387	38	82613	20777	41	79223	18
43	11550	32	88450	14346	35	85654	17441	39	82559	20836	42	79164	17
44	11594	32	88406	14395	36	85605	17495	40	82505	20895	43	79105	16
45	11638	33	88362	14444	37	85556	17550	41	82450	20954	44	79046	15
46	11683	34	88317	14493	38	85507	17604	41	82396	21014	45	78986	14
47	11727	35	88273	14543	39	85457	17658	42	82342	21073	46	78927	13
48	11772	35	88228	14592	40	85408	17713	43	82287	21133	47	78867	12
49	11816	36	88184	14642	41	85358	17767	44	82233	21192	48	78808	11
50	11861	37	88139	14691	42	85309	17822	45	82178	21252	49	78748	10
51	11905	38	88095	14741	42	85259	17877	46	82123	21311	50	78689	9
52	11950	38	88050	14791	43	85209	17931	47	82069	21371	51	78629	8
53	11995	39	88005	14841	44	85159	17986	48	82014	21431	52	78569	7
54	12040	40	87960	14891	45	85109	18041	49	81959	21491	54	78509	6
55	12085	41	87915	14941	45	85059	18096	50	81904	21551	55	78449	5
56	12130	41	87870	14991	46	85009	18151	50	81849	21611	56	78389	4
57	12175	42	87825	15041	47	84959	18207	51	81793	21671	57	78329	3
58	12221	43	87779	15091	48	84909	18262	52	81738	21732	58	78268	2
59	12266	44	87734	15142	49	84858	18317	53	81683	21792	59	78208	1
60	12312	44	87688	15192	50	84808	18373	54	81627	21852	60	78148	0
″ Vers.	Suvers.	Parts for ″	Vers.	Suvers	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	′ ″ Suv.
	171°			170°			169°			168°			

TABLE XXVIII.

Decimal Versed and Suversed Sines.

′ / ″ Vers.	12° Vers.	12° Parts for ″	12° Suvers.	13° Vers.	13° Parts for ″	13° Suvers.	14° Vers.	14° Parts for ″	14° Suvers.	15° Vers.	15° Parts for ″	15° Suvers.	″ Suv.
0	21852	0	78148	25630	0	74370	29704	0	70296	34074	0	65926	60
1	21913	1	78087	25695	1	74305	29775	1	70225	34149	1	65851	59
2	21973	2	78027	25761	2	74239	29845	2	70155	34225	2	65775	58
3	22034	3	77966	25827	3	74173	29916	3	70084	34300	4	65700	57
4	22095	4	77905	25892	4	74108	29986	5	70014	34376	5	65624	56
5	22156	5	77844	25958	6	74042	30057	6	69943	34452	6	65548	55
6	22217	6	77783	26024	7	73976	30128	7	69872	34527	8	65473	54
7	22278	7	77722	26090	8	73910	30199	8	69801	34603	9	65397	53
8	22339	8	77661	26156	9	73844	30270	9	69730	34679	10	65321	52
9	22400	9	77600	26222	10	73778	30341	10	69659	34755	11	65245	51
10	22461	10	77539	26288	11	73712	30412	12	69588	34831	13	65169	50
11	22523	11	77477	26355	13	73645	30483	13	69517	34907	14	65093	49
12	22584	12	77416	26421	14	73579	30555	14	69445	34983	15	65017	48
13	22646	13	77354	26488	15	73512	30626	15	69374	35060	16	64940	47
14	22707	14	77293	26554	16	73446	30697	16	69303	35136	18	64864	46
15	22769	15	77231	26621	17	73379	30769	18	69231	35213	19	64787	45
16	22831	16	77169	26687	18	73313	30841	19	69159	35289	20	64711	44
17	22892	17	77108	26754	19	73246	30912	20	69088	35366	21	64634	43
18	22954	18	77046	26821	20	73179	30984	21	69016	35443	23	64557	42
19	23016	19	76984	26888	21	73112	31056	22	68944	35519	24	64481	41
20	23078	20	76922	26955	22	73045	31128	24	68872	35596	26	64404	40
21	23141	22	76859	27022	24	72978	31200	25	68800	35673	27	64327	39
22	23203	23	76797	27089	25	72911	31272	26	68728	35750	28	64250	38
23	23265	24	76735	27157	26	72843	31344	27	68656	35827	29	64173	37
24	23328	25	76672	27224	27	72776	31417	28	68583	35905	31	64095	36
25	23390	26	76610	27292	28	72708	31489	30	68511	35982	32	64018	35
26	23453	27	76547	27359	29	72641	31562	31	68438	36059	33	63941	34
27	23515	28	76485	27427	30	72573	31634	32	68366	36137	34	63863	33
28	23578	29	76422	27494	31	72506	31707	33	68293	36214	36	63786	32
29	23641	30	76359	27562	32	72438	31780	34	68220	36292	37	63708	31
30	23704	31	76296	27630	34	72370	31852	36	68148	36369	38	63631	30
31	23767	32	76233	27698	35	72302	31925	37	68075	36447	40	63553	29
32	23830	33	76170	27766	36	72234	31998	38	68002	36525	42	63475	28
33	23893	35	76107	27834	38	72166	32071	40	67929	36603	43	63397	27
34	23956	36	76044	27902	39	72098	32144	41	67856	36681	44	63319	26
35	24020	37	75980	27971	40	72029	32217	43	67783	36759	46	63241	25
36	24083	38	75917	28039	41	71961	32291	44	67709	36837	47	63163	24
37	24147	39	75853	28107	42	71893	32364	45	67636	36916	48	63084	23
38	24210	40	75790	28176	44	71824	32438	47	67562	36994	49	63006	22
39	24274	41	75726	28245	45	71755	32511	48	67489	37072	51	62928	21
40	24338	42	75662	28313	46	71687	32585	49	67415	37151	52	62849	20
41	24401	43	75599	28382	47	71618	32658	50	67342	37230	53	62770	19
42	24465	44	75535	28451	48	71549	32732	52	67268	37308	55	62692	18
43	24529	45	75471	28520	49	71480	32806	53	67194	37387	56	62613	17
44	24593	46	75407	28589	50	71411	32880	54	67120	37466	57	62534	16
45	24658	47	75342	28658	52	71342	32954	55	67046	37545	59	62455	15
46	24722	49	75278	28727	53	71273	33028	57	66972	37624	60	62376	14
47	24786	50	75214	28796	54	71204	33102	58	66898	37703	61	62297	13
48	24851	51	75149	28866	55	71134	33177	59	66823	37782	63	62218	12
49	24915	52	75085	28935	56	71065	33251	60	66749	37861	64	62139	11
50	24980	53	75020	29005	57	70995	33325	62	66675	37941	65	62059	10
51	25044	54	74956	29074	59	70926	33400	63	66600	38020	67	61980	9
52	25109	55	74891	29144	60	70856	33474	64	66526	38099	68	61901	8
53	25174	56	74826	29214	61	70786	33549	65	66451	38179	69	61821	7
54	25239	57	74761	29283	62	70717	33624	66	66376	38259	71	61741	6
55	25304	58	74696	29353	63	70647	33699	68	66301	38338	72	61662	5
56	25369	59	74631	29423	64	70577	33774	69	66226	38418	73	61582	4
57	25434	60	74566	29493	66	70507	33849	70	66151	38498	75	61502	3
58	25499	61	74501	29564	67	70436	33924	72	66076	38578	76	61422	2
59	25564	62	74436	29634	68	70366	33999	73	66001	38658	78	61342	1
60	25630	64	74370	29704	69	70296	34074	74	65926	38738	79	61262	0
″ Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	′ / ″ Suv.
	167°			166°			165°			164°			

TABLE XXVIII.

Decimal Versed and Suversed Sines.

′	16°			17°			18°			19°			′
″ Vers.	Vers.	Parts for ″	Suvers.	Vers.	Parts for ″	Suvers.	Vers.	Parts for ″	Suvers.	Vers.	Parts for ″	Suvers.	″ Suv.
0	38738	0	61262	43695	0	56305	48943	0	51057	54481	0	45519	60
1	38818	1	61182	43780	1	56220	49033	2	50967	54576	2	45424	59
2	38899	3	61101	43865	3	56135	49123	3	50877	54671	3	45329	58
3	38979	4	61021	43951	4	56049	49213	5	50787	54766	5	45234	57
4	39060	5	60940	44036	6	55964	49304	6	50696	54861	6	45139	56
5	39140	7	60860	44121	7	55879	49394	8	50606	54956	8	45044	55
6	39221	8	60779	44207	9	55793	49484	9	50516	55051	10	44949	54
7	39302	9	60698	44293	10	55707	49575	11	50425	55146	11	44854	53
8	39382	11	60618	44378	11	55622	49665	12	50335	55242	13	44758	52
9	39463	12	60537	44464	13	55536	49756	14	50244	55337	14	44663	51
10	39544	14	60456	44550	14	55450	49846	15	50154	55432	16	44568	50
11	39625	15	60375	44636	16	55364	49937	17	50063	55528	18	44472	49
12	39706	16	60294	44722	17	55278	50028	18	49972	55624	19	44376	48
13	39787	18	60213	44808	19	55192	50119	20	49881	55719	21	44281	47
14	39869	19	60131	44894	20	55106	50210	21	49790	55815	22	44185	46
15	39950	20	60050	44980	22	55020	50301	23	49699	55911	24	44089	45
16	40032	22	59968	45066	23	54934	50392	24	49608	56007	26	43993	44
17	40113	23	59887	45153	24	54847	50483	26	49517	56103	27	43897	43
18	40195	24	59805	45239	26	54761	50574	27	49426	56199	29	43801	42
19	40276	26	59724	45326	27	54674	50666	29	49334	56295	30	43705	41
20	40358	27	59642	45412	29	54588	50757	30	49243	56391	32	43609	40
21	40440	28	59560	45499	30	54501	50849	32	49151	56488	34	43512	39
22	40522	30	59478	45586	32	54414	50940	33	49060	56584	35	43416	38
23	40604	31	59396	45673	33	54327	51032	35	48968	56681	37	43319	37
24	40686	32	59314	45760	35	54240	51124	36	48876	56777	38	43223	36
25	40768	34	59232	45847	36	54153	51216	38	48784	56874	40	43126	35
26	40850	35	59150	45934	37	54066	51308	39	48692	56971	42	43029	34
27	40933	36	59067	46021	39	53979	51400	41	48600	57068	43	42932	33
28	41015	38	58985	46108	40	53892	51492	42	48508	57164	45	42836	32
29	41098	39	58902	46196	42	53804	51584	44	48416	57261	47	42739	31
30	41180	41	58820	46283	44	53717	51676	46	48324	57358	48	42642	30
31	41263	43	58737	46371	45	53629	51769	48	48231	57456	51	42544	29
32	41346	44	58654	46458	47	53542	51861	50	48139	57553	52	42447	28
33	41428	46	58572	46546	48	53454	51954	51	48046	57650	54	42350	27
34	41511	47	58489	46634	50	53366	52046	53	47954	57747	56	42253	26
35	41594	49	58406	46721	51	53279	52139	54	47861	57845	57	42155	25
36	41677	50	58323	46809	53	53191	52232	56	47768	57942	59	42058	24
37	41761	51	58239	46897	55	53103	52324	57	47676	58040	60	41960	23
38	41844	53	58156	46985	56	53015	52417	59	47583	58138	62	41862	22
39	41927	54	58073	47074	58	52926	52510	61	47490	58236	64	41764	21
40	42010	55	57990	47162	59	52838	52603	62	47397	58333	66	41667	20
41	42094	57	57906	47250	61	52750	52696	64	47304	58431	67	41569	19
42	42177	58	57823	47338	62	52662	52790	65	47210	58529	69	41471	18
43	42261	59	57739	47427	64	52573	52883	67	47117	58628	71	41372	17
44	42345	61	57655	47516	65	52484	52976	68	47024	58726	72	41274	16
45	42429	62	57571	47604	67	52396	53070	70	46930	58824	74	41176	15
46	42512	64	57488	47693	68	52307	53163	71	46837	58922	75	41078	14
47	42596	65	57404	47782	70	52218	53257	73	46743	59021	77	40979	13
48	42680	66	57320	47871	71	52129	53351	75	46649	59119	79	40881	12
49	42765	68	57235	47960	73	52040	53444	76	46556	59218	80	40782	11
50	42849	69	57151	48049	74	51951	53538	78	46462	59316	82	40684	10
51	42933	71	57067	48138	76	51862	53632	79	46368	59415	84	40585	9
52	43017	72	56983	48227	77	51773	53726	81	46274	59514	85	40486	8
53	43102	74	56898	48316	79	51684	53820	82	46180	59613	87	40387	7
54	43186	75	56814	48406	80	51594	53915	84	46085	59712	89	40288	6
55	43271	77	56729	48495	82	51505	54009	85	45991	59811	90	40189	5
56	43356	78	56644	48585	83	51415	54103	87	45897	59910	92	40090	4
57	43440	80	56560	48674	85	51326	54198	88	45802	60009	94	39991	3
58	43525	81	56475	48764	86	51236	54292	90	45708	60109	95	39891	2
59	43610	82	56390	48854	88	51146	54387	92	45613	60208	97	39792	1
60	43695	83	56305	48943	89	51057	54481	93	45519	60307	98	39693	0
″ Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	′ ″ Suv.
	163°			162°			161°			160°			

TABLE XXVIII.

Decimal Versed and Suversed Sines.

′ / ″ Vers.	20° Vers.	Parts for ″	20° Suvers.	21° Vers.	Parts for ″	21° Suvers.	22° Vers.	Parts for ″	22° Suvers.	23° Vers.	Parts for ″	23° Suvers	′ / ″ Suv.
0	60307	0	39693	66420	0	33580	72816	0	27184	79495	0	20505	60
1	60407	2	39593	66524	2	33476	72925	2	27075	79609	2	20391	59
2	60506	3	39494	66628	4	33372	73034	4	26966	79723	4	20277	58
3	60606	5	39394	66733	5	33267	73143	5	26857	79836	6	20164	57
4	60706	7	39294	66837	7	33163	73253	7	26747	79950	8	20050	56
5	60806	8	39194	66942	9	33058	73362	9	26638	80064	10	19936	55
6	60906	10	39094	67046	11	32954	73471	11	26529	80178	11	19822	54
7	61006	12	38994	67151	12	32849	73581	13	26419	80293	13	19707	53
8	61106	13	38894	67256	14	32744	73690	15	26310	80407	15	19593	52
9	61206	15	38794	67361	16	32639	73800	17	26200	80521	17	19479	51
10	61306	17	38694	67466	18	32534	73910	18	26090	80636	19	19364	50
11	61407	18	38593	67571	19	32429	74019	20	25981	80750	21	19250	49
12	61507	20	38493	67676	21	32324	74129	22	25871	80865	23	19135	48
13	61607	22	38393	67781	23	32219	74239	24	25761	80979	25	19021	47
14	61708	23	38292	67887	25	32113	74349	26	25651	81094	27	18906	46
15	61809	25	38191	67992	26	32008	74459	28	25541	81209	29	18791	45
16	61909	27	38091	68098	28	31902	74570	29	25430	81324	31	18676	44
17	62010	28	37990	68203	30	31797	74680	31	25320	81439	33	18561	43
18	62111	30	37889	68309	32	31691	74790	33	25210	81554	35	18446	42
19	62212	32	37788	68414	33	31586	74901	35	25099	81669	37	18331	41
20	62313	34	37687	68520	35	31480	75011	37	24989	81784	38	18216	40
21	62414	35	37586	68626	37	31374	75122	39	24878	81899	40	18101	39
22	62515	37	37485	68732	39	31268	75232	40	24768	82014	42	17986	38
23	62617	39	37383	68838	40	31162	75343	42	24657	82130	44	17870	37
24	62718	40	37282	68944	42	31056	75454	44	24546	82245	46	17755	36
25	62819	42	37181	69050	44	30950	75565	46	24435	82361	48	17639	35
26	62921	44	37079	69157	46	30843	75676	48	24324	82477	50	17523	34
27	63023	46	36977	69263	48	30737	75787	50	24213	82592	52	17408	33
28	63124	47	36876	69369	50	30631	75898	52	24102	82708	54	17292	32
29	63226	49	36774	69476	52	30524	76009	54	23991	82824	56	17176	31
30	63328	51	36672	69582	53	30418	76120	56	23880	82940	58	17060	30
31	63430	53	36570	69689	55	30311	76232	58	23768	83056	60	16944	29
32	63532	55	36468	69796	57	30204	76343	60	23657	83172	62	16828	28
33	63634	57	36366	69903	59	30097	76455	62	23545	83288	64	16712	27
34	63736	58	36264	70009	61	29991	76566	64	23434	83404	66	16596	26
35	63838	60	36162	70116	63	29884	76678	65	23322	83521	68	16479	25
36	63940	62	36060	70223	65	29777	76790	67	23210	83637	70	16363	24
37	64043	63	35957	70331	67	29669	76902	69	23098	83754	72	16246	23
38	64145	65	35855	70438	69	29562	77013	71	22987	83870	74	16130	22
39	64248	67	35752	70545	71	29455	77125	73	22875	83987	76	16013	21
40	64350	69	35650	70652	72	29348	77238	75	22762	84104	78	15896	20
41	64453	70	35547	70760	74	29240	77350	77	22650	84220	80	15780	19
42	64556	72	35444	70867	76	29133	77462	79	22538	84337	82	15663	18
43	64659	74	35341	70975	78	29025	77574	81	22426	84454	84	15546	17
44	64762	75	35238	71083	80	28917	77687	83	22313	84571	86	15429	16
45	64865	77	35135	71190	81	28810	77799	84	22201	84688	88	15312	15
46	64968	79	35032	71298	83	28702	77912	86	22088	84806	90	15194	14
47	65071	81	34929	71406	85	28594	78024	88	21976	84923	92	15077	13
48	65174	82	34826	71514	87	28486	78137	90	21863	85040	94	14960	12
49	65278	84	34722	71622	89	28378	78250	92	21750	85158	96	14842	11
50	65381	86	34619	71730	90	28270	78362	94	21638	85275	98	14725	10
51	65485	87	34515	71839	92	28161	78475	96	21525	85393	100	14607	9
52	65588	89	34412	71947	94	28053	78588	98	21412	85510	102	14490	8
53	65692	91	34308	72055	96	27945	78701	100	21299	85628	104	14372	7
54	65795	93	34205	72164	98	27836	78815	101	21185	85746	106	14254	6
55	65899	95	34101	72272	100	27728	78928	103	21072	85864	108	14136	5
56	66003	96	33997	72381	101	27619	79041	105	20959	85982	110	14018	4
57	66107	98	33893	72490	103	27510	79154	107	20846	86100	112	13900	3
58	66211	100	33789	72598	105	27402	79268	109	20732	86218	114	13782	2
59	66315	101	33685	72707	107	27293	79381	110	20619	86336	116	13664	1
60	66420	103	33580	72816	109	27184	79495	112	20505	86454	118	13546	0
″ Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	′ / ″ Suv.
	159°			158°			157°			156°			

TABLE XXVIII.

Decimal Versed and Suversed Sines.

′	24°			25°			26°			27°			
″ Vers.	Vers.	Parts for ″	Suvers.	Vers.	Parts for ″	Suvers.	Vers.	Parts for ″	Suvers.	Vers.	Parts for ″	Suvers.	″ Suv.
0	86454	0	13546	93692	0	06308	01206	0	98794	08993	0	91007	60
1	86573	2	13427	93815	2	06185	01333	2	98667	09126	2	90874	59
2	86691	4	13309	93938	4	06062	01461	4	98539	09258	4	90742	58
3	86810	6	13190	94061	6	05939	01589	6	98411	09390	6	90610	57
4	86928	8	13072	94185	8	05815	01717	8	98283	09522	8	90478	56
5	87047	10	12953	94308	10	05692	01844	11	98156	09655	11	90345	55
6	87166	12	12834	94431	12	05569	01972	13	98028	09787	13	90213	54
7	87285	14	12715	94555	14	05445	02100	15	97900	09920	15	90080	53
8	87403	16	12597	94678	16	05322	02228	17	97772	10052	17	89948	52
9	87522	18	12478	94802	18	05198	02357	19	97643	10185	19	89815	51
10	87642	20	12358	94925	21	05075	02485	21	97515	10318	21	89682	50
11	87761	22	12239	95049	23	04951	02613	23	97387	10451	23	89549	49
12	87880	24	12120	95173	25	04827	02742	26	97258	10584	26	89416	48
13	87999	26	12001	95297	27	04703	02870	28	97130	10717	28	89283	47
14	88118	28	11882	95421	29	04579	02999	30	97001	10850	30	89150	46
15	88238	30	11762	95545	31	04455	03127	32	96873	10983	32	89017	45
16	88357	32	11643	95669	33	04331	03256	34	96744	11116	35	88884	44
17	88477	34	11523	95793	35	04207	03385	36	96615	11249	37	88751	43
18	88597	36	11403	95917	37	04083	03514	38	96486	11383	39	88617	42
19	88716	38	11284	96042	39	03958	03642	40	96358	11516	41	88484	41
20	88836	40	11164	96166	41	03834	03771	43	96229	11650	44	88350	40
21	88956	42	11044	96291	43	03709	03901	45	96099	11783	46	88217	39
22	89076	44	10924	96415	45	03585	04030	47	95970	11917	48	88083	38
23	89196	46	10804	96540	47	03460	04159	49	95841	12051	50	87949	37
24	89316	48	10684	96665	49	03335	04288	52	95712	12185	52	87815	36
25	89436	50	10564	96789	51	03211	04418	54	95582	12318	55	87682	35
26	89557	52	10443	96914	54	03086	04547	57	95453	12452	58	87548	34
27	89677	54	10323	97039	56	02961	04677	58	95323	12587	60	87413	33
28	89798	56	10202	97164	58	02836	04806	60	95194	12721	62	87279	32
29	89918	58	10082	97289	60	02711	04936	62	95064	12855	64	87145	31
30	90039	60	09961	97415	63	02585	05066	65	94934	12989	67	87011	30
31	90159	62	09841	97540	65	02460	05195	67	94805	13123	69	86877	29
32	90280	64	09720	97665	67	02335	05325	69	94675	13258	71	86742	28
33	90401	66	09599	97791	69	02209	05455	71	94545	13392	74	86608	27
34	90522	68	09478	97916	71	02084	05585	73	94415	13527	76	86473	26
35	90643	70	09357	98042	73	01958	05716	75	94284	13662	78	86338	25
36	90764	72	09236	98167	75	01833	05846	78	94154	13796	81	86204	24
37	90885	74	09115	98293	77	01707	05976	80	94024	13931	83	86069	23
38	91006	76	08994	98419	79	01581	06106	82	93894	14066	85	85934	22
39	91127	78	08873	98545	81	01455	06237	84	93763	14201	87	85799	21
40	91249	80	08751	98671	84	01329	06367	86	93633	14336	90	85664	20
41	91370	82	08630	98797	86	01203	06498	89	93502	14471	92	85529	19
42	91492	84	08508	98923	88	01077	06629	91	93371	14606	94	85394	18
43	91613	86	08387	99049	90	00951	06759	93	93241	14742	96	85258	17
44	91735	88	08265	99175	92	00825	06890	95	93110	14877	98	85123	16
45	91857	90	08143	99302	95	00698	07021	97	92979	15012	101	84988	15
46	91979	92	08021	99428	97	00572	07152	100	92848	15148	103	84852	14
47	92100	94	07900	99555	99	00445	07283	102	92717	15283	105	84717	13
48	92222	96	07778	99681	101	00319	07414	104	92586	15419	107	84581	12
49	92345	98	07655	99808	103	00192	07545	106	92455	15555	110	84445	11
50	92467	100	07533	99935	105	00065	07677	108	92323	15690	112	84310	10
51	92589	102	07411	00061	107	99939	07808	111	92192	15826	114	84174	9
52	92711	104	07289	00188	109	99812	07939	113	92061	15962	116	84038	8
53	92833	106	07167	00315	111	99685	08071	115	91929	16098	119	83902	7
54	92956	109	07044	00442	113	99558	08202	117	91798	16234	121	83766	6
55	93078	111	06922	00569	116	99431	08334	119	91666	16370	124	83630	5
56	93201	113	06799	00696	118	99304	08466	122	91534	16507	126	83493	4
57	93324	115	06676	00824	120	99176	08598	124	91402	16643	129	83357	3
58	93446	117	06554	00951	122	99049	08729	126	91271	16779	131	83221	2
59	93569	119	06431	01078	124	98922	08861	129	91139	16916	133	83084	1
60	93692	121	06308	01206	127	98794	08993	131	91007	17052	136	82948	0
″ Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	′ ″ Suv.
	155°			154°			153°			152°			

TABLE XXVIII.

Decimal Versed and Suversed Sines.

′ [″ Vers.]	28°			29°			30°			31°			[″ Suv.]
	Vers.	Parts for ″	Suvers.	Vers.	Parts for ″	Suvers.	Vers.	Parts for ″	Suvers.	Vers.	Parts for ″	Suvers.	
0	17052	0	82948	25380	0	74620	33975	0	66025	42833	0	57167	60
1	17189	2	82811	25521	2	74479	34120	2	65880	42983	3	57017	59
2	17326	4	82674	25662	5	74338	34266	5	65734	43132	5	56868	58
3	17462	6	82538	25804	7	74196	34411	7	65589	43282	8	56718	57
4	17599	9	82401	25945	9	74055	34557	9	65443	43433	10	56567	56
5	17736	11	82264	26086	12	73914	34703	12	65297	43583	13	56417	55
6	17873	13	82127	26228	14	73772	34849	15	65151	43733	15	56267	54
7	18010	16	81990	26369	16	73631	34994	17	65006	43883	17	56117	53
8	18147	18	81853	26511	19	73489	35140	19	64860	44034	20	55966	52
9	18284	21	81716	26652	21	73348	35287	22	64713	44184	22	55816	51
10	18422	23	81578	26794	24	73206	35433	24	64567	44334	25	55666	50
11	18559	25	81441	26936	26	73064	35579	27	64421	44485	27	55515	49
12	18696	27	81304	27078	29	72922	35725	29	64275	44636	30	55364	48
13	18834	30	81166	27220	31	72780	35872	32	64128	44786	32	55214	47
14	18972	32	81028	27362	33	72638	36018	34	63982	44937	35	55063	46
15	19109	34	80891	27504	36	72496	36164	37	63836	45088	38	54912	45
16	19247	37	80753	27646	38	72354	36311	39	63689	45239	40	54761	44
17	19385	39	80615	27788	40	72212	36458	41	63542	45390	43	54610	43
18	19523	41	80477	27931	43	72069	36604	44	63396	45541	45	54459	42
19	19661	43	80339	28073	45	71927	36751	46	63249	45692	47	54308	41
20	19799	46	80201	28216	47	71784	36898	49	63102	45844	50	54156	40
21	19937	48	80063	28358	49	71642	37045	51	62955	45995	52	54005	39
22	20075	52	79925	28501	52	71499	37192	54	62808	46146	55	53854	38
23	20213	54	79787	28643	54	71357	37339	56	62661	46298	57	53702	37
24	20351	56	79649	28786	56	71214	37486	59	62514	46449	60	53551	36
25	20490	58	79510	28929	59	71071	37634	61	62366	46601	62	53399	35
26	20628	60	79372	29072	61	70928	37781	63	62219	46752	65	53248	34
27	20767	62	79233	29215	64	70785	37928	66	62072	46904	67	53096	33
28	20905	64	79095	29358	66	70642	38076	68	61924	47056	70	52944	32
29	21044	67	78956	29501	69	70499	38223	71	61777	47208	73	52792	31
30	21183	69	78817	29644	71	70356	38371	74	61629	47360	76	52640	30
31	21322	71	78678	29788	74	70212	38518	77	61482	47512	78	52488	29
32	21461	73	78539	29931	77	70069	38666	80	61334	47664	81	52336	28
33	21600	76	78400	30074	79	69926	38814	82	61186	47816	83	52184	27
34	21739	78	78261	30218	82	69782	38962	84	61038	47968	85	52032	26
35	21878	81	78122	30361	84	69639	39110	87	60890	48121	88	51879	25
36	22017	84	77983	30505	87	69495	39258	89	60742	48273	90	51727	24
37	22156	86	77844	30649	89	69351	39406	92	60594	48425	93	51575	23
38	22296	89	77704	30793	91	69207	39554	94	60446	48578	96	51422	22
39	22435	91	77565	30936	94	69064	39702	97	60298	48731	99	51269	21
40	22575	93	77425	31080	96	68920	39851	99	60149	48883	102	51117	20
41	22714	95	77286	31224	98	68776	39999	102	60001	49036	105	50964	19
42	22854	97	77146	31368	101	68632	40148	103	59852	49189	107	50811	18
43	22994	100	77006	31513	103	68487	40296	106	59704	49342	109	50658	17
44	23133	102	76867	31657	105	68343	40445	109	59555	49495	111	50505	16
45	23273	105	76727	31801	108	68199	40594	112	59406	49648	114	50352	15
46	23413	107	76587	31946	110	68054	40742	114	59258	49801	117	50199	14
47	23553	109	76447	32090	112	67910	40891	116	59109	49954	119	50046	13
48	23693	112	76307	32234	115	67766	41040	118	58960	50107	122	49893	12
49	23833	114	76167	32379	117	67621	41189	121	58811	50261	125	49739	11
50	23974	117	76026	32524	119	67476	41338	124	58662	50414	128	49586	10
51	24114	119	75886	32669	122	67331	41487	126	58513	50567	131	49433	9
52	24254	122	75746	32813	124	67187	41636	129	58364	50721	133	49279	8
53	24395	124	75605	32958	127	67042	41786	131	58214	50875	135	49125	7
54	24535	126	75465	33103	129	66897	41935	134	58065	51028	138	48972	6
55	24676	129	75324	33248	132	66752	42084	136	57916	51182	140	48818	5
56	24817	131	75183	33393	134	66607	42234	139	57766	51336	143	48664	4
57	24958	133	75042	33539	137	66461	42384	142	57616	51490	145	48510	3
58	25098	136	74902	33684	139	66316	42533	145	57467	51644	148	48356	2
59	25239	138	74761	33829	142	66171	42683	147	57317	51798	151	48202	1
60	25380	140	74620	33975	144	66025	42833	149	57167	51952	153	48048	0
[″ Vers.]	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	′ [″ Suv.]
	151°			150°			149°			148°			

TABLE XXVIII.

Decimal Versed and Suversed Sines.

′	32°			33°			34°			35°			
″ Vers.	Vers.	Parts for ″	Suvers.	Vers.	Parts for ″	Suvers.	Vers.	Parts for ″	Suvers.	Vers.	Parts for ″	Suvers.	″ Suv.
0	51952	0	48048	61329	0	38671	70962	0	29038	80848	0	19152	60
1	52106	3	47894	61488	3	38512	71125	3	28875	81015	3	18985	59
2	52260	5	47740	61646	5	38354	71288	6	28712	81182	6	18818	58
3	52415	8	47585	61805	8	38195	71451	8	28549	81349	9	18651	57
4	52569	10	47431	61964	11	38036	71614	11	28386	81516	11	18484	56
5	52723	13	47277	62122	13	37878	71777	14	28223	81683	14	18317	55
6	52878	16	47122	62281	16	37719	71940	16	28060	81850	17	18150	54
7	53033	18	46967	62440	19	37560	72103	19	27897	82018	20	17982	53
8	53187	20	46813	62599	22	37401	72266	22	27734	82185	23	17815	52
9	53342	23	46658	62758	24	37242	72429	25	27571	82352	25	17648	51
10	53497	26	46503	62917	27	37083	72593	27	27407	82520	28	17480	50
11	53652	28	46348	63076	29	36924	72756	30	27244	82687	31	17313	49
12	53807	31	46193	63236	32	36764	72919	33	27081	82855	34	17145	48
13	53962	33	46038	63395	35	36605	73083	36	26917	83023	36	16977	47
14	54117	36	45883	63554	38	36446	73247	38	26753	83191	39	16809	46
15	54272	39	45728	63714	40	36286	73410	41	26590	83358	42	16642	45
16	54427	41	45573	63873	43	36127	73574	44	26426	83526	44	16474	44
17	54583	44	45417	64033	46	35967	73738	47	26262	83694	47	16306	43
18	54738	47	45262	64193	48	35807	73902	49	26098	83862	50	16138	42
19	54894	49	45106	64352	51	35648	74066	52	25934	84030	53	15970	41
20	55049	52	44951	64512	54	35488	74230	55	25770	84199	56	15801	40
21	55205	54	44795	64672	56	35328	74394	57	25606	84367	58	15633	39
22	55360	57	44640	64832	59	35168	74558	60	25442	84535	61	15465	38
23	55516	60	44484	64992	62	35008	74722	63	25278	84704	64	15296	37
24	55672	62	44328	65152	65	34848	74887	65	25113	84872	67	15128	36
25	55828	65	44172	65312	67	34688	75051	68	24949	85041	70	14959	35
26	55984	68	44016	65472	70	34528	75215	71	24785	85209	73	14791	34
27	56140	72	43860	65633	72	34367	75380	73	24620	85378	76	14622	33
28	56296	74	43704	65793	75	34206	75544	76	24456	85547	79	14453	32
29	56452	76	43548	65954	78	34046	75709	79	24291	85716	82	14284	31
30	56609	78	43391	66114	81	33886	75874	82	24126	85884	84	14116	30
31	56765	81	43235	66275	84	33725	76039	84	23961	86053	87	13947	29
32	56921	84	43079	66435	87	33565	76203	87	23797	86222	90	13778	28
33	57078	87	42922	66596	90	33404	76368	90	23632	86392	93	13608	27
34	57234	90	42766	66757	93	33243	76533	93	23467	86561	95	13439	26
35	57391	92	42609	66918	95	33082	76698	96	23302	86730	98	13270	25
36	57548	94	42452	67079	98	32921	76864	99	23136	86899	101	13101	24
37	57704	97	42296	67240	101	32760	77029	102	22971	87069	104	12931	23
38	57861	99	42139	67401	103	32599	77194	105	22806	87238	107	12762	22
39	58018	102	41982	67562	106	32438	77360	108	22640	87408	110	12592	21
40	58175	105	41825	67723	108	32277	77525	111	22475	87577	113	12423	20
41	58332	108	41668	67885	111	32115	77690	114	22310	87747	115	12253	19
42	58489	111	41511	68046	114	31954	77856	116	22144	87916	118	12084	18
43	58646	113	41354	68207	116	31793	78022	119	21978	88086	121	11914	17
44	58804	115	41196	68369	119	31631	78187	122	21813	88256	124	11744	16
45	58961	118	41039	68530	121	31470	78353	125	21647	88426	127	11574	15
46	59118	121	40882	68692	124	31308	78519	128	21481	88596	130	11404	14
47	59276	123	40724	68854	127	31146	78685	131	21315	88766	133	11234	13
48	59433	126	40567	69016	129	30984	78851	134	21149	88936	136	11064	12
49	59591	128	40409	69177	132	30823	79017	136	20983	89106	139	10894	11
50	59749	131	40251	69339	135	30661	79183	139	20817	89277	142	10723	10
51	59906	134	40094	69501	138	30499	79349	142	20651	89447	144	10553	9
52	60064	136	39936	69663	141	30337	79515	145	20485	89617	147	10383	8
53	60222	139	39778	69826	143	30174	79682	147	20318	89788	150	10212	7
54	60380	142	39620	69988	146	30012	79848	150	20152	89958	155	10042	6
55	60538	144	39462	70150	148	29850	80015	153	19985	90129	156	09871	5
56	60696	147	39304	70312	151	29688	80181	156	19819	90300	159	09700	4
57	60854	150	39146	70475	154	29525	80348	158	19652	90470	162	09530	3
58	61013	152	38987	70637	156	29363	80514	161	19486	90641	164	09359	2
59	61171	155	38829	70800	159	29200	80681	164	19319	90812	167	09188	1
60	61329	157	38671	70962	162	29038	80848	166	19152	90983	170	09017	0
″ Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	′ ″ Suv.
	147°			146°			145°			144°			

TABLE XXVIII.

Decimal Versed and Suversed Sines.

′ / ′ Vers.	36° Vers.	36° Parts for ″	36° Suvers.	37° Vers.	37° Parts for ″	37° Suvers.	38° Vers.	38° Parts for ″	38° Suvers.	39° Vers.	39° Parts for ″	39° Suvers.	″ Suv.
0	90983	0	09017	01364	0	98636	11989	0	88011	22854	0	77146	60
1	91154	3	08846	01540	3	98460	12168	3	87832	23037	3	76963	59
2	91325	6	08675	01715	6	98285	12348	6	87652	23220	6	76780	58
3	91496	9	08504	01890	9	98110	12527	9	87473	23404	9	76596	57
4	91667	11	08333	02065	12	97935	12706	12	87294	23587	12	76413	56
5	91839	14	08161	02241	15	97759	12886	15	87114	23770	15	76230	55
6	92010	17	07990	02416	18	97584	13065	18	86935	23954	18	76046	54
7	92181	20	07819	02592	20	97408	13244	21	86756	24137	21	75863	53
8	92353	23	07647	02767	23	97233	13424	24	86576	24321	24	75679	52
9	92525	26	07475	02943	26	97057	13604	27	86396	24504	27	75496	51
10	92696	29	07304	03119	29	96881	13783	30	86217	24688	31	75312	50
11	92868	32	07132	03294	32	96706	13963	33	86037	24872	34	75128	49
12	93040	34	06960	03470	35	96530	14143	36	85857	25056	37	74945	48
13	93211	37	06789	03646	38	96354	14323	39	85677	25239	40	74761	47
14	93383	40	06617	03822	41	96178	14503	42	85497	25423	43	74577	46
15	93555	43	06445	03998	44	96002	14683	45	85317	25607	46	74393	45
16	93727	46	06273	04174	47	95826	14863	48	85137	25791	49	74209	44
17	93899	49	06101	04350	50	95650	15043	51	84957	25976	52	74024	43
18	94072	52	05928	04527	53	95473	15224	54	84776	26160	55	73840	42
19	94244	55	05756	04703	56	95297	15404	57	84596	26344	58	73656	41
20	94416	57	05584	04879	59	95121	15584	60	84416	26528	61	73472	40
21	94589	60	05411	05056	62	94944	15765	63	84235	26713	65	73287	39
22	94761	63	05239	05232	65	94768	15945	66	84055	26897	68	73103	38
23	94934	66	05066	05409	68	94591	16126	69	83874	27082	71	72918	37
24	95106	69	04894	05585	71	94415	16306	72	83694	27266	74	72734	36
25	95279	72	04721	05762	74	94238	16487	75	83513	27451	77	72549	35
26	95452	75	04548	05939	76	94061	16668	78	83332	27636	80	72364	34
27	95624	78	04376	06116	79	93884	16849	81	83151	27821	83	72179	33
28	95797	81	04203	06293	82	93707	17030	84	82970	28006	86	71994	32
29	95970	84	04030	06470	85	93530	17211	87	82789	28190	89	71810	31
30	96143	86	03857	06647	88	93353	17392	90	82608	28375	92	71625	30
31	96316	89	03684	06824	92	93176	17573	94	82427	28560	97	71440	29
32	96489	92	03511	07001	95	92999	17754	97	82246	28746	100	71254	28
33	96662	95	03338	07178	98	92822	17935	100	82065	28931	103	71069	27
34	96836	98	03164	07356	101	92644	18117	103	81883	29116	106	70884	26
35	97009	101	02991	07533	104	92467	18298	106	81702	29301	109	70699	25
36	97182	104	02818	07710	107	92290	18480	109	81520	29487	112	70513	24
37	97356	107	02644	07888	110	92112	18661	112	81339	29672	115	70328	23
38	97529	110	02471	08065	113	91935	18843	115	81157	29858	118	70142	22
39	97703	113	02297	08243	116	91757	19024	118	80976	30043	121	69957	21
40	97877	116	02123	08421	119	91579	19206	121	80794	30229	124	69771	20
41	98050	118	01950	08599	121	91401	19388	125	80612	30415	127	69585	19
42	98224	121	01776	08776	124	91224	19570	128	80430	30601	130	69399	18
43	98398	124	01602	08954	127	91046	19752	131	80249	30786	133	69214	17
44	98572	127	01428	09132	130	90868	19934	134	80067	30972	136	69028	16
45	98746	130	01254	09310	133	90690	20116	137	79384	31158	139	68842	15
46	98920	133	01080	09488	136	90512	20298	140	79702	31344	143	68656	14
47	99094	136	00906	09667	139	90333	20480	143	79520	31530	146	68470	13
48	99269	139	00731	09845	142	90155	20662	146	79338	31717	149	68283	12
49	99443	142	00557	10023	145	89977	20844	149	79156	31903	152	68097	11
50	99617	145	00383	10202	148	89798	21027	152	78973	32089	155	67911	10
51	99792	147	00208	10380	151	89620	21209	155	78791	32275	158	67725	9
52	99966	150	00034	10559	154	89441	21392	158	78608	32462	161	67538	8
53	00140	153	99860	10737	157	89263	21574	161	78426	32648	164	67352	7
54	00315	156	99685	10916	160	89084	21757	164	78243	32835	167	67165	6
55	00490	159	99510	11095	163	88905	21940	167	78060	33021	171	66979	5
56	00665	162	99335	11273	166	88727	22122	170	77878	33208	174	66792	4
57	00840	165	99160	11452	169	88548	22305	173	77695	33395	177	66605	3
58	01014	168	98986	11631	172	88369	22488	176	77512	33582	180	66418	2
59	01189	171	98811	11810	175	88190	22671	179	77329	33769	183	66231	1
60	01364	174	98636	11989	178	88011	22854	182	77146	33956	186	66044	0
″ Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	′ ″ Suv.
	143°			142°			141°			140°			

TABLE XXVIII.

Decimal Versed and Suversed Sines.

′	40°			41°			42°			43°			
″ Vers.	Vers.	Parts for ″	Suvers.	Vers.	Parts for ″	Suvers.	Vers.	Parts for ″	Suvers.	Vers.	Parts for ″	Suvers.	″ Suv.
0	33956	0	66044	45290	0	54710	56855	0	43145	68646	0	31354	60
1	34143	3	65857	45481	3	54519	57050	3	42950	68845	3	31155	59
2	34330	6	65670	45672	6	54328	57245	7	42755	69043	7	30957	58
3	34517	9	65483	45863	10	54137	57439	10	42561	69242	10	30758	57
4	34704	13	65296	46054	13	53946	57634	13	42366	69440	13	30560	56
5	34891	16	65109	46245	16	53755	57829	17	42171	69639	16	30361	55
6	35079	19	64921	46437	19	53563	58024	20	41976	69838	20	30162	54
7	35266	22	64734	46628	22	53372	58219	23	41781	70037	23	29963	53
8	35453	25	64547	46819	25	53181	58414	26	41586	70235	26	29765	52
9	35641	28	64359	47011	28	52989	58610	29	41390	70434	29	29566	51
10	35829	31	64171	47202	32	52798	58805	33	41195	70633	33	29367	50
11	36016	34	63984	47394	35	52606	59000	36	41000	70832	36	29168	49
12	36204	38	63796	47585	38	52415	59195	39	40805	71031	39	28969	48
13	36392	41	63608	47777	41	52223	59391	42	40609	71230	42	28770	47
14	36580	44	63420	47968	44	52032	59586	45	40414	71430	46	28570	46
15	36768	47	63232	48160	48	51840	59782	49	40218	71629	50	28371	45
16	36956	50	63044	48352	51	51648	59978	52	40022	71828	53	28172	44
17	37144	53	62856	48544	54	51456	60173	55	39827	72028	56	27972	43
18	37332	57	62668	48736	57	51264	60369	58	39631	72227	60	27773	42
19	37520	60	62480	48928	60	51072	60565	62	39435	72427	63	27573	41
20	37708	63	62292	49120	64	50880	60761	65	39239	72626	66	27374	40
21	37896	66	62104	49312	67	50688	60957	68	39043	72826	70	27174	39
22	38085	69	61915	49504	70	50496	61153	71	38847	73026	73	26974	38
23	38273	72	61727	49697	73	50303	61349	75	38651	73226	76	26774	37
24	38462	75	61538	49889	76	50111	61545	78	38455	73425	80	26575	36
25	38650	78	61350	50081	80	49919	61741	81	38259	73625	83	26375	35
26	38839	82	61161	50274	83	49726	61937	84	38063	73825	86	26175	34
27	39028	85	60972	50466	86	49534	62133	88	37867	74025	90	25975	33
28	39216	88	60784	50659	89	49341	62330	91	37670	74225	93	25775	32
29	39405	91	60595	50852	92	49148	62526	94	37474	74425	96	25575	31
30	39594	94	60406	51044	96	48956	62723	98	37277	74626	100	25374	30
31	39783	98	60217	51237	101	48763	62919	103	37081	74826	104	25174	29
32	39972	101	60028	51430	104	48570	63116	106	36884	75026	107	24974	28
33	40161	105	59839	51623	107	48377	63313	110	36687	75227	110	24773	27
34	40350	108	59650	51816	110	48184	63509	113	36491	75427	113	24573	26
35	40539	111	59461	52009	113	47991	63706	116	36294	75628	117	24372	25
36	40729	114	59271	52202	117	47798	63903	119	36097	75828	120	24172	24
37	40918	117	59082	52395	120	47605	64100	123	35900	76029	123	23971	23
38	41107	120	58893	52588	123	47412	64297	126	35703	76230	127	23770	22
39	41297	123	58703	52782	126	47218	64494	129	35506	76430	130	23570	21
40	41486	127	58514	52975	129	47025	64691	132	35309	76631	134	23369	20
41	41676	130	58324	53168	133	46832	64888	135	35112	76832	137	23168	19
42	41866	133	58134	53362	136	46638	65085	139	34915	77034	141	22966	18
43	42055	136	57945	53555	139	46445	65284	142	34716	77234	144	22766	17
44	42245	139	57755	53749	142	46251	65480	145	34520	77435	147	22565	16
45	42435	142	57565	53943	145	46057	65678	149	34322	77636	150	22364	15
46	42625	146	57375	54136	149	45864	65875	152	34125	77837	154	22163	14
47	42815	149	57185	54330	152	45670	66073	155	33927	78039	157	21961	13
48	43005	152	56995	54524	155	45476	66270	158	33730	78240	161	21760	12
49	43195	155	56805	54718	159	45282	66468	162	33532	78441	164	21559	11
50	43385	158	56615	54912	162	45088	66666	165	33334	78643	168	21357	10
51	43575	161	56425	55106	166	44894	66863	169	33137	78844	171	21156	9
52	43766	165	56234	55300	169	44700	67061	172	32939	79046	174	20954	8
53	43956	168	56044	55494	172	44506	67259	175	32741	79247	177	20753	7
54	44146	171	55854	55688	175	44312	67457	178	32543	79449	181	20551	6
55	44337	174	55663	55883	178	44117	67655	182	32345	79651	184	20349	5
56	44528	177	55472	56077	181	43923	67853	185	32147	79852	188	20148	4
57	44718	180	55282	56272	184	43728	68051	188	31949	80054	191	19946	3
58	44909	184	55091	56466	188	43534	68250	191	31750	80256	194	19744	2
59	45100	187	54900	56661	191	43339	68448	194	31552	80458	197	19542	1
60	45290	190	54710	56855	194	43145	68646	197	31354	80660	201	19340	0
″ Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	′ ″ Suv.
	139°			138°			137°			136°			

TABLE XXVIII.

Decimal Versed and Suversed Sines.

′ / ″ Vers.	44° Vers.	44° Parts for ″	44° Suvers.	45° Vers.	45° Parts for ″	45° Suvers.	46° Vers.	46° Parts for ″	46° Suvers.	47° Vers.	47° Parts for ″	47° Suvers.	″ Suv. ′
0	80660	0	19340	92893	0	07107	05342	0	94658	18002	0	81998	60
1	80862	3	19138	93099	3	06901	05551	3	94449	18214	4	81786	59
2	81065	7	18936	93305	7	06695	05760	7	94240	18427	7	81573	58
3	81267	10	18733	93511	10	06489	05970	11	94030	18640	10	81360	57
4	81469	14	18531	93716	14	06284	06179	14	93821	18853	14	81147	56
5	81671	17	18329	93922	17	06078	06389	18	93611	19066	18	80934	55
6	81874	20	18126	94128	21	05872	06598	21	93402	19279	21	80721	54
7	82076	24	17924	94334	24	05666	06808	25	93192	19492	25	80508	53
8	82279	27	17721	94541	28	05459	07018	28	92982	19705	28	80295	52
9	82481	31	17519	94747	31	05253	07227	32	92773	19919	32	80081	51
10	82684	34	17316	94953	34	05047	07437	35	92563	20132	36	79868	50
11	82887	38	17113	95159	38	04841	07647	39	92353	20345	39	79655	49
12	83089	41	16911	95366	41	04634	07857	42	92143	20559	43	79441	48
13	83292	45	16708	95572	45	04428	08067	46	91933	20772	46	79228	47
14	83495	48	16505	95779	48	04221	08277	49	91723	20986	50	79014	46
15	83698	51	16302	95985	52	04015	08487	52	91513	21199	53	78801	45
16	83901	55	16099	96192	55	03808	08697	56	91303	21413	57	78587	44
17	84104	58	15896	96399	59	03601	08907	59	91093	21627	60	78373	43
18	84307	62	15693	96605	62	03395	09118	63	90882	21840	64	78160	42
19	84511	65	15490	96812	66	03188	09328	66	90672	22054	67	77946	41
20	84714	68	15286	97019	69	02981	09538	70	90462	22268	71	77732	40
21	84917	72	15083	97226	73	02774	09749	73	90251	22482	74	77518	39
22	85120	75	14880	97433	76	02567	09959	77	90041	22696	78	77304	38
23	85324	79	14676	97640	80	02360	10170	80	89830	22910	81	77090	37
24	85527	82	14473	97847	83	02153	10380	84	89620	23124	85	76876	36
25	85731	85	14269	98054	86	01946	10591	87	89409	23338	89	76662	35
26	85934	88	14066	98261	90	01739	10802	91	89198	23552	92	76448	34
27	86138	92	13862	98469	93	01531	11013	94	88987	23767	96	76233	33
28	86342	96	13658	98676	97	01324	11224	98	88776	23981	99	76019	32
29	86546	99	13454	98883	100	01117	11435	101	88565	24195	103	75805	31
30	86750	102	13251	99091	103	00909	11645	105	88355	24410	107	75590	30
31	86954	106	13047	99298	107	00702	11857	110	88143	24624	111	75376	29
32	87157	109	12843	99506	111	00494	12068	113	87932	24839	115	75161	28
33	87362	112	12639	99713	114	00287	12279	117	87721	25053	118	74947	27
34	87566	116	12434	99921	118	00079	12490	120	87510	25268	122	74732	26
35	87770	119	12230	00129	121	99871	12701	124	87299	25483	125	74517	25
36	87974	123	12026	00337	125	99663	12914	127	87086	25698	129	74302	24
37	88178	126	11822	00545	128	99456	13124	131	86876	25912	133	74088	23
38	88383	130	11617	00752	132	99248	13335	134	86665	26127	136	73873	22
39	88587	133	11413	00960	135	99040	13547	138	86453	26342	140	73658	21
40	88791	137	11209	01169	139	98832	13758	141	86242	26557	143	73443	20
41	88996	140	11004	01377	142	98623	13970	144	86030	26772	147	73228	19
42	89201	143	10800	01585	145	98415	14182	148	85818	26988	151	73012	18
43	89405	146	10595	01793	149	98207	14393	152	85607	27203	154	72797	17
44	89611	150	10390	02001	152	97999	14605	156	85395	27418	158	72582	16
45	89815	153	10185	02210	156	97791	14817	159	85183	27633	161	72367	15
46	90019	157	09981	02418	159	97582	15029	163	84971	27849	165	72151	14
47	90224	160	09776	02626	163	97374	15241	167	84759	28064	169	71936	13
48	90429	164	09571	02835	166	97165	15453	170	84547	28279	172	71721	12
49	90634	167	09366	03044	170	96957	15665	174	84335	28495	176	71505	11
50	90839	171	09161	03252	173	96748	15877	177	84123	28710	179	71290	10
51	91044	174	08956	03461	177	96539	16089	181	83911	28926	183	71074	9
52	91250	177	08750	03670	180	96330	16302	184	83698	29142	186	70858	8
53	91455	181	08545	03878	184	96122	16514	188	83486	29358	190	70642	7
54	91660	184	08340	04087	187	95913	16726	191	83274	29573	193	70427	6
55	91865	188	08135	04296	191	95704	16939	195	83061	29789	197	70211	5
56	92071	191	07929	04505	194	95495	17151	198	82849	30005	201	69995	4
57	92276	195	07724	04714	198	95286	17364	202	82636	30221	204	69779	3
58	92482	198	07518	04923	201	95077	17576	205	82424	30437	208	69563	2
59	92688	202	07312	05132	205	94868	17789	209	82211	30653	211	69347	1
60	92893	205	07107	05342	208	94658	18002	212	81998	30869	214	69131	0
″ Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	′ ″ Suv.
	135°			134°			133°			132°			

TABLE XXVIII.

Decimal Versed and Suversed Sines.

′ / ″ Vers.	48° Vers.	48° Parts for ″	48° Suvers.	49° Vers.	49° Parts for ″	49° Suvers.	50° Vers.	50° Parts for ″	50° Suvers.	51° Vers.	51° Parts for ″	51° Suvers.	″ Suv. ′
0	30869	0	69131	43941	0	56059	57212	0	42788	70680	0	29320	60
1	31086	4	68914	44160	4	55840	57435	4	42565	70906	4	29094	59
2	31302	7	68698	44380	7	55620	57658	8	42342	71132	8	28868	58
3	31518	11	68482	44600	11	55400	57881	11	42119	71358	11	28642	57
4	31735	14	68265	44820	15	55180	58104	15	41896	71584	15	28416	56
5	31951	18	68049	45039	19	54961	58327	19	41673	71811	19	28189	55
6	32167	22	67833	45259	22	54741	58550	22	41450	72037	23	27963	54
7	32384	25	67616	45479	26	54521	58774	26	41226	72263	26	27737	53
8	32601	29	67399	45699	30	54301	58997	30	41003	72490	30	27510	52
9	32817	32	67183	45919	33	54081	59220	34	40780	72716	34	27284	51
10	33034	36	66966	46139	37	53861	59443	37	40557	72943	38	27057	50
11	33251	39	66749	46359	41	53641	59667	41	40333	73170	42	26830	49
12	33468	43	66532	46579	44	53421	59890	45	40110	73396	45	26604	48
13	33684	46	66316	46800	48	53200	60114	49	39886	73623	49	26377	47
14	33901	50	66099	47020	52	52980	60337	53	39663	73850	53	26150	46
15	34118	54	65882	47240	55	52760	60561	56	39439	74077	57	25923	45
16	34335	57	65665	47461	59	52539	60785	60	39215	74303	61	25697	44
17	34553	61	65447	47681	63	52319	61008	64	38992	74530	64	25470	43
18	34770	64	65230	47902	66	52098	61232	68	38768	74757	68	25243	42
19	34987	68	65013	48122	70	51878	61456	72	38544	74984	72	25016	41
20	35204	72	64796	48343	73	51657	61680	75	38320	75212	76	24788	40
21	35421	75	64579	48563	77	51437	61904	78	38096	75439	80	24561	39
22	35639	79	64361	48784	81	51216	62128	82	37872	75666	84	24334	38
23	35856	82	64144	49005	85	50995	62352	86	37648	75893	88	24107	37
24	36074	86	63926	49226	89	50774	62576	90	37424	76120	92	23880	36
25	36291	90	63709	49447	93	50553	62800	94	37200	76348	95	23652	35
26	36509	93	63491	49668	96	50332	63024	97	36976	76575	99	23425	34
27	36727	97	63273	49889	100	50111	63249	101	36751	76803	103	23197	33
28	36944	101	63056	50110	103	49890	63473	105	36527	77030	107	22970	32
29	37162	105	62838	50331	107	49669	63697	109	36303	77258	111	22742	31
30	37380	109	62620	50552	110	49448	63922	112	36078	77485	114	22515	30
31	37598	114	62402	50773	115	49227	64146	117	35854	77713	119	22287	29
32	37816	118	62184	50994	118	49006	64371	121	35629	77941	123	22059	28
33	38034	121	61966	51216	122	48784	64595	124	35405	78169	127	21831	27
34	38252	125	61748	51437	126	48563	64820	128	35180	78396	131	21604	26
35	38470	128	61530	51659	129	48341	65045	131	34955	78624	134	21376	25
36	38688	132	61312	51880	133	48120	65270	134	34730	78852	138	21148	24
37	38906	136	61094	52102	137	47898	65494	138	34506	79080	142	20920	23
38	39125	139	60875	52323	141	47677	65719	142	34281	79308	146	20692	22
39	39343	143	60657	52545	144	47455	65944	146	34056	79536	150	20464	21
40	39561	146	60439	52767	148	47233	66169	150	33831	79765	153	20235	20
41	39780	150	60220	52988	152	47012	66394	153	33606	79993	157	20007	19
42	39998	154	60002	53210	155	46790	66619	157	33381	80221	161	19779	18
43	40217	157	59783	53432	159	46568	66844	161	33156	80449	165	19551	17
44	40435	161	59565	53654	163	46346	67069	165	32931	80678	169	19322	16
45	40654	164	59346	53876	167	46124	67295	169	32705	80906	172	19094	15
46	40873	168	59127	54098	171	45902	67520	172	32480	81135	176	18865	14
47	41092	172	58908	54320	174	45680	67745	176	32255	81363	180	18637	13
48	41310	175	58690	54542	178	45458	67971	180	32029	81592	184	18408	12
49	41529	179	58471	54765	181	45235	68196	183	31804	81820	188	18180	11
50	41748	183	58252	54987	185	45013	68422	187	31578	82049	191	17951	10
51	41967	187	58033	55208	188	44792	68647	191	31353	82278	195	17722	9
52	42187	190	57813	55432	192	44568	68873	195	31127	82506	199	17494	8
53	42406	194	57594	55654	196	44346	69099	199	30901	82735	203	17265	7
54	42625	197	57375	55876	200	44124	69324	202	30676	82964	206	17036	6
55	42844	201	57156	56099	204	43901	69550	206	30450	83193	210	16807	5
56	43063	204	56937	56322	207	43678	69776	210	30224	83422	214	16578	4
57	43283	208	56717	56544	211	43456	70002	214	29998	83651	218	16349	3
58	43502	212	56498	56767	215	43233	70228	218	29772	83880	221	16120	2
59	43722	215	56278	56990	218	43010	70454	221	29546	84109	225	15891	1
60	43941	219	56059	57212	222	42788	70680	225	29320	84339	228	15661	0
″ Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	′ ″ Suv.
	131°			130°			129°			128°			

TABLE XXVIII.

Decimal Versed and Suversed Sines.

′ / ″ Vers.	52°			53°			54°			55°			′ / ″ Suv.
	Vers.	Parts for ″	Suvers.	Vers.	Parts for ″	Suvers.	Vers.	Parts for ″	Suvers.	Vers.	Parts for ″	Suvers.	
0	84339	0	15661	98185	0	01815	12215	0	87785	26424	0	73576	60
1	84568	4	15432	98417	4	01583	12450	4	87550	26662	4	73338	59
2	84797	8	15203	98650	8	01350	12685	8	87315	26900	8	73100	58
3	85026	12	14974	98882	12	01118	12921	12	87079	27139	12	72861	57
4	85256	16	14744	99115	16	00885	13157	16	86843	27377	16	72623	56
5	85485	19	14515	99347	19	00653	13392	20	86608	27616	20	72384	55
6	85715	23	14285	99580	23	00420	13628	24	86372	27854	24	72146	54
7	85944	27	14056	99812	27	00188	13863	28	86137	28093	28	71907	53
8	86174	31	13826	00045	31	99955	14099	32	85901	28331	32	71669	52
9	86404	35	13596	00278	35	99722	14335	36	85665	28570	36	71430	51
10	86633	38	13367	00511	39	99489	14571	39	85429	28809	40	71191	50
11	86863	42	13137	00744	43	99256	14806	43	85194	29048	44	70952	49
12	87093	46	12907	00976	47	99024	15042	47	84958	29286	48	70714	48
13	87323	50	12677	01209	50	98791	15278	51	84722	29525	52	70475	47
14	87553	54	12447	01442	54	98558	15514	55	84486	29764	56	70236	46
15	87783	57	12217	01675	58	98325	15750	59	84250	30003	60	69997	45
16	88013	61	11987	01909	62	98091	15986	63	84014	30242	64	69758	44
17	88243	65	11757	02142	66	97858	16223	67	83777	30481	68	69519	43
18	88473	69	11527	02375	70	97625	16459	71	83541	30720	72	69280	42
19	88703	73	11297	02608	74	97392	16695	75	83305	30960	76	69040	41
20	88933	77	11067	02841	78	97159	16931	79	83069	31199	80	68801	40
21	89164	81	10836	03075	82	96925	17168	83	82832	31438	84	68562	39
22	89394	85	10606	03308	86	96692	17404	87	82596	31678	88	68322	38
23	89624	89	10376	03542	90	96458	17640	91	82360	31917	92	68083	37
24	89855	92	10145	03775	94	96225	17877	95	82123	32156	96	67844	36
25	90085	96	09915	04009	98	95991	18114	99	81886	32396	100	67604	35
26	90316	100	09684	04242	102	95758	18350	103	81650	32635	104	67365	34
27	90547	104	09453	04476	106	95524	18587	107	81413	32875	108	67125	33
28	90777	108	09223	04710	110	95290	18824	111	81176	33114	112	66886	32
29	91008	111	08992	04943	114	95057	19060	115	80940	33354	116	66646	31
30	91239	115	08761	05177	117	94823	19297	118	80703	33594	120	66406	30
31	91469	119	08531	05411	121	94589	19534	122	80466	33834	124	66166	29
32	91700	123	08300	05645	125	94355	19771	126	80229	34073	128	65927	28
33	91931	127	08069	05879	129	94121	20008	130	79992	34313	132	65687	27
34	92162	131	07838	06113	133	93887	20245	134	79755	34553	136	65447	26
35	92393	135	07607	06347	137	93653	20482	138	79518	34793	140	65207	25
36	92624	139	07376	06581	141	93419	20719	142	79281	35033	144	64967	24
37	92855	143	07145	06815	145	93185	20956	146	79044	35273	148	64727	23
38	93086	147	06914	07050	149	92950	21193	150	78807	35513	152	64487	22
39	93318	151	06682	07284	153	92716	21430	154	78570	35753	156	64247	21
40	93549	154	06451	07518	156	92482	21668	158	78332	35993	160	64007	20
41	93780	158	06220	07752	160	92248	21905	162	78095	36234	164	63766	19
42	94012	162	05988	07987	164	92013	22142	166	77858	36474	168	63526	18
43	94243	166	05757	08221	168	91779	22380	170	77620	36714	172	63286	17
44	94475	170	05525	08456	172	91544	22617	174	77383	36955	176	63045	16
45	94706	174	05294	08690	176	91310	22855	178	77145	37195	180	62805	15
46	94938	178	05062	08925	180	91075	23092	182	76908	37436	184	62564	14
47	95169	182	04831	09160	184	90840	23330	186	76670	37676	188	62324	13
48	95401	186	04599	09394	188	90606	23568	190	76432	37917	192	62083	12
49	95633	190	04367	09629	192	90371	23805	194	76195	38157	196	61843	11
50	95864	194	04136	09864	195	90136	24043	198	75957	38398	200	61602	10
51	96096	197	03904	10099	199	89901	24281	202	75719	38639	204	61361	9
52	96328	201	03672	10334	203	89666	24519	206	75481	38879	208	61121	8
53	96560	205	03440	10569	207	89431	24757	210	75243	39120	212	60880	7
54	96792	209	03208	10804	211	89196	24995	214	75005	39361	216	60639	6
55	97024	213	02976	11039	215	88961	25233	218	74767	39602	220	60398	5
56	97256	217	02744	11274	219	88726	25471	222	74529	39843	224	60157	4
57	97488	220	02512	11509	223	88491	25709	226	74291	40084	228	59916	3
58	97720	224	02280	11744	227	88256	25947	230	74053	40325	232	59675	2
59	97953	228	02047	11979	231	88021	26185	234	73815	40566	236	59434	1
60	98185	231	01815	12215	234	87785	26424	237	73576	40807	240	59193	0
′ / ″ Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	′ / ″ Suv.
	127°			126°			125°			124°			

TABLE XXVIII.

Decimal Versed and Suversed Sines.

′ / ″ Vers.	56°			57°			58°			59°			′ / ″ Suv.
	Vers.	Parts for ″	Suvers.	Vers.	Parts for ″	Suvers.	Vers.	Parts for ″	Suvers.	Vers.	Parts for ″	Suvers.	
0	40807	0	59193	55361	0	44639	70081	0	29919	84962	0	15038	60
1	41048	4	58952	55605	4	44395	70327	4	29673	85211	4	14789	59
2	41290	8	58710	55849	8	44151	70574	8	29426	85461	8	14539	58
3	41531	12	58469	56093	12	43907	70821	12	29179	85710	12	14290	57
4	41772	16	58228	56337	16	43663	71068	17	28932	85960	17	14040	56
5	42014	20	57986	56581	20	43419	71315	21	28685	86209	21	13791	55
6	42255	24	57745	56826	24	43174	71562	25	28438	86459	25	13541	54
7	42496	28	57504	57070	28	42930	71809	29	28191	86708	29	13292	53
8	42738	32	57262	57314	32	42686	72056	33	27944	86958	33	13042	52
9	42979	36	57021	57558	37	42442	72303	37	27697	87208	37	12792	51
10	43221	40	56779	57803	41	42197	72550	41	27450	87457	42	12543	50
11	43463	45	56537	58047	45	41953	72797	45	27203	87707	46	12293	49
12	43704	49	56296	58292	49	41708	73044	49	26956	87957	50	12043	48
13	43946	53	56054	58536	53	41464	73291	54	26709	88207	54	11793	47
14	44188	57	55812	58781	57	41219	73539	58	26461	88457	58	11543	46
15	44430	61	55570	59025	61	40975	73786	62	26214	88707	63	11293	45
16	44672	65	55328	59270	65	40730	74033	66	25967	88957	67	11043	44
17	44914	69	55086	59515	69	40485	74281	70	25719	89207	71	10793	43
18	45156	73	54844	59760	73	40240	74528	74	25472	89457	75	10543	42
19	45398	77	54602	60004	77	39996	74776	78	25224	89707	79	10293	41
20	45640	81	54360	60249	81	39751	75023	82	24977	89957	83	10043	40
21	45882	85	54118	60494	86	39506	75271	87	24729	90208	87	09792	39
22	46124	89	53876	60739	90	39261	75519	91	24481	90458	91	09542	38
23	46366	93	53634	60984	94	39016	75766	95	24234	90708	95	09292	37
24	46609	97	53391	61229	98	38771	76014	99	23986	90959	99	09041	36
25	46851	101	53149	61474	102	38526	76262	103	23738	91209	104	08791	35
26	47093	105	52907	61719	106	38281	76510	107	23490	91459	108	08541	34
27	47336	109	52664	61965	110	38035	76758	111	23242	91710	112	08290	33
28	47578	113	52422	62210	114	37790	77005	115	22995	91960	117	08040	32
29	47820	117	52180	62455	118	37545	77253	119	22747	92211	121	07789	31
30	48063	122	51937	62700	122	37300	77501	124	22499	92462	126	07538	30
31	48306	126	51694	62946	127	37054	77749	128	22251	92712	130	07288	29
32	48548	130	51452	63191	131	36809	77998	132	22002	92963	134	07037	28
33	48791	134	51209	63437	135	36563	78246	136	21754	93214	138	06786	27
34	49034	138	50966	63682	139	36318	78494	141	21506	93464	142	06536	26
35	49276	142	50724	63928	143	36072	78742	145	21258	93715	146	06285	25
36	49519	146	50481	64173	148	35827	78990	149	21010	93966	151	06034	24
37	49762	150	50238	64419	152	35581	79239	153	20761	94217	155	05783	23
38	50005	154	49995	64664	156	35336	79487	158	20513	94468	159	05532	22
39	50248	158	49752	64910	160	35090	79735	162	20265	94719	163	05281	21
40	50491	162	49509	65156	164	34844	79984	166	20016	94970	168	05030	20
41	50734	166	49266	65402	168	34598	80232	170	19768	95221	172	04779	19
42	50977	171	49023	65648	172	34352	80481	174	19519	95472	176	04528	18
43	51220	175	48780	65893	176	34107	80729	178	19271	95723	180	04277	17
44	51464	179	48536	66139	180	33861	80978	182	19022	95975	184	04025	16
45	51707	183	48293	66385	184	33615	81227	187	18773	96226	188	03774	15
46	51950	187	48050	66631	189	33369	81475	191	18525	96477	193	03523	14
47	52193	191	47807	66878	193	33122	81724	195	18276	96729	197	03271	13
48	52437	195	47563	67124	197	32876	81973	199	18027	96980	201	03020	12
49	52680	199	47320	67370	201	32630	82222	203	17778	97231	205	02769	11
50	52924	203	47076	67616	205	32384	82471	207	17529	97483	210	02517	10
51	53167	207	46833	67862	209	32138	82720	212	17280	97734	214	02266	9
52	53411	211	46589	68109	213	31891	82969	216	17031	97986	218	02014	8
53	53654	215	46346	68355	217	31645	83218	220	16782	98238	222	01762	7
54	53898	219	46102	68601	221	31399	83467	224	16533	98489	226	01511	6
55	54142	223	45858	68848	226	31152	83716	228	16284	98741	230	01259	5
56	54386	227	45614	69094	230	30906	83965	233	16035	98993	235	01007	4
57	54629	231	45371	69341	234	30659	84214	237	15786	99244	239	00756	3
58	54873	235	45127	69587	238	30413	84463	241	15537	99496	243	00504	2
59	55117	239	44883	69834	242	30166	84713	245	15287	99748	247	00252	1
60	55361	243	44639	70081	246	29919	84962	249	15038	00000	251	00000	0
″ Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	′ / ″ Suv.
	123°			122°			121°			120°			

TABLE XXVIII.

Decimal Versed and Suversed Sines.

′	60°			61°			62°			63°			′
″ Vers.	Vers.	Parts for ″	Suvers.	Vers.	Parts for ″	Suvers.	Vers.	Parts for ″	Suvers.	Vers.	Parts for ″	Suvers.	″ Suv.
0	00000	0	00000	15190	0	84810	30528	0	69472	46009	0	53991	60
1	00252	4	99748	15445	4	84555	30785	4	69215	46269	4	53731	59
2	00504	8	99496	15699	8	84301	31042	8	68958	46528	9	53472	58
3	00756	12	99244	15954	13	84046	31299	13	68701	46787	13	53213	57
4	01008	17	98992	16208	17	83792	31556	17	68444	47046	17	52954	56
5	01260	21	98740	16463	21	83537	31813	21	68187	47306	22	52694	55
6	01512	25	98488	16718	25	83282	32070	26	67930	47565	26	52435	54
7	01764	30	98236	16972	30	83028	32327	30	67673	47825	30	52175	53
8	02017	34	97983	17227	34	82773	32584	34	67416	48084	35	51916	52
9	02269	38	97731	17482	38	82518	32842	38	67158	48344	39	51656	51
10	02521	42	97479	17737	43	82263	33099	43	66901	48603	43	51397	50
11	02774	46	97226	17991	47	82009	33356	47	66644	48863	48	51137	49
12	03026	50	96974	18246	51	81754	33613	51	66387	49122	52	50878	48
13	03278	54	96722	18501	55	81499	33871	55	66129	49382	56	50618	47
14	03531	58	96469	18756	59	81244	34128	60	65872	49642	61	50358	46
15	03783	63	96217	19011	63	80989	34385	64	65615	49902	65	50098	45
16	04036	67	95964	19266	67	80734	34643	68	65357	50161	69	49839	44
17	04289	71	95711	19521	72	80479	34900	72	65100	50421	74	49579	43
18	04541	75	95459	19776	76	80224	35158	77	64842	50681	78	49319	42
19	04794	79	95206	20032	80	79968	35415	81	64585	50941	82	49059	41
20	05047	84	94953	20287	85	79713	35673	85	64327	51201	87	48799	40
21	05299	88	94701	20542	89	79458	35931	90	64069	51461	91	48539	39
22	05552	92	94448	20797	93	79203	36188	94	63812	51721	95	48279	38
23	05805	96	94195	21053	97	78947	36446	98	63554	51981	100	48019	37
24	06058	100	93942	21308	101	78692	36704	103	63296	52241	104	47759	36
25	06311	105	93689	21564	106	78436	36962	107	63038	52501	108	47499	35
26	06564	109	93436	21819	110	78181	37219	111	62781	52761	113	47239	34
27	06817	113	93183	22074	115	77926	37477	115	62523	53021	117	46979	33
28	07070	117	92930	22330	119	77670	37735	120	62265	53282	121	46718	32
29	07323	121	92677	22586	123	77414	37993	124	62007	53542	126	46458	31
30	07576	126	92424	22841	128	77159	38251	129	61749	53802	130	46198	30
31	07830	131	92170	23097	132	76903	38509	133	61491	54062	134	45938	29
32	08083	135	91917	23353	136	76647	38767	138	61233	54323	139	45677	28
33	08336	140	91664	23608	141	76392	39026	142	60974	54583	143	45417	27
34	08589	144	91411	23864	145	76136	39284	146	60716	54844	147	45156	26
35	08843	148	91157	24120	149	75880	39542	151	60458	55104	152	44896	25
36	09096	152	90904	24376	154	75624	39800	155	60200	55365	156	44635	24
37	09350	156	90650	24632	158	75368	40058	159	59942	55625	160	44375	23
38	09603	161	90397	24888	162	75112	40317	164	59683	55886	165	44114	22
39	09857	165	90143	25144	166	74856	40575	168	59425	56147	169	43853	21
40	10110	169	89890	25400	171	74600	40833	172	59167	56407	174	43593	20
41	10364	173	89636	25656	175	74344	41092	177	58908	56668	178	43332	19
42	10617	178	89383	25912	179	74088	41350	181	58650	56929	182	43071	18
43	10871	182	89129	26168	183	73832	41609	185	58391	57190	187	42810	17
44	11125	186	88875	26424	187	73576	41867	189	58133	57450	191	42550	16
45	11379	190	88621	26680	192	73320	42126	194	57874	57711	195	42289	15
46	11633	195	88367	26937	196	73063	42385	198	57615	57972	199	42028	14
47	11886	199	88114	27193	200	72807	42643	202	57357	58233	204	41767	13
48	12140	203	87860	27449	204	72551	42902	207	57098	58494	208	41506	12
49	12394	207	87606	27706	208	72294	43161	211	56839	58755	212	41245	11
50	12648	212	87352	27962	213	72038	43420	215	56580	59016	217	40984	10
51	12902	216	87098	28218	217	71782	43678	220	56322	59277	221	40723	9
52	13156	220	86844	28475	221	71525	43937	224	56063	59538	226	40462	8
53	13410	224	86590	28731	225	71269	44196	228	55804	59800	230	40200	7
54	13665	229	86335	28988	230	71012	44455	233	55545	60061	234	39939	6
55	13919	233	86081	29245	234	70755	44714	237	55286	60322	239	39678	5
56	14173	237	85827	29501	238	70499	44973	241	55027	60583	243	39417	4
57	14427	241	85573	29758	242	70242	45232	246	54768	60845	247	39155	3
58	14682	245	85318	30015	247	69985	45491	250	54509	61106	251	38894	2
59	14936	249	85064	30272	251	69728	45750	254	54250	61367	256	38633	1
60	15190	254	84810	30528	256	69472	46009	258	53991	61629	260	38371	0
″ Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	′ ″ Suv.
	119°			118°			117°			116°			

TABLE XXVIII.

Decimal Versed and Suversed Sines.

′	64°			65°			66°			67°			
″ Vers.	Vers.	Parts for ″	Suvers.	Vers.	Parts for ″	Suvers.	Vers.	Parts for ″	Suvers.	Vers.	Parts for ″	Suvers.	″ Suv.
0	61629	0	38371	77382	0	22618	93263	0	06737	09269	0	90731	60
1	61890	4	38110	77645	4	22355	93529	4	06471	09537	4	90463	59
2	62152	9	37848	77909	9	22091	93795	9	06205	09804	9	90196	58
3	62413	13	37587	78173	13	21827	94061	13	05939	10072	13	89928	57
4	62675	17	37325	78437	18	21563	94327	18	05673	10340	18	89660	56
5	62937	22	37063	78700	22	21300	94592	22	05408	10608	22	89392	55
6	63198	26	36802	78964	26	21036	94858	27	05142	10876	27	89124	54
7	63460	31	36540	79228	31	20772	95124	31	04876	11144	31	88856	53
8	63722	35	36278	79492	35	20508	95390	36	04610	11412	36	88588	52
9	63983	39	36017	79756	40	20244	95656	40	04344	11680	40	88320	51
10	64245	44	35755	80020	44	19980	95922	44	04078	11948	45	88052	50
11	64507	48	35493	80284	48	19716	96189	49	03811	12216	49	87784	49
12	64769	52	35231	80548	53	19452	96455	53	03545	12484	54	87516	48
13	65031	57	34969	80812	57	19188	96721	58	03279	12753	58	87247	47
14	65293	61	34707	81076	62	18924	96987	62	03013	13021	63	86979	46
15	65555	66	34445	81340	66	18660	97253	66	02747	13289	67	86711	45
16	65817	70	34183	81604	71	18396	97520	71	02480	13557	72	86443	44
17	66079	74	33921	81869	75	18131	97786	76	02214	13826	76	86174	43
18	66341	79	33659	82133	79	17867	98052	80	01948	14094	81	85906	42
19	66603	83	33397	82397	84	17603	98319	85	01681	14362	85	85638	41
20	66865	87	33135	82661	88	17339	98585	89	01415	14631	89	85369	40
21	67127	92	32873	82926	92	17074	98851	94	01149	14899	93	85101	39
22	67390	96	32610	83190	97	16810	99118	98	00882	15168	98	84832	38
23	67652	100	32348	83455	101	16545	99384	103	00616	15436	102	84564	37
24	67914	105	32086	83719	106	16281	99651	107	00349	15705	107	84295	36
25	68177	109	31823	83984	110	16016	99917	112	00083	15973	111	84027	35
26	68439	113	31561	84248	114	15752	00184	116	99816	16242	116	83758	34
27	68701	118	31299	84513	119	15487	00451	121	99549	16510	121	83490	33
28	68964	122	31036	84777	123	15223	00717	125	99283	16779	125	83221	32
29	69226	126	30774	85042	128	14958	00984	129	99016	17048	130	82952	31
30	69489	131	30511	85307	132	14693	01251	133	98749	17317	134	82683	30
31	69751	136	30249	85571	137	14429	01518	138	98482	17585	139	82415	29
32	70014	140	29986	85836	141	14164	01784	142	98216	17854	143	82146	28
33	70277	145	29723	86101	146	13899	02051	147	97949	18123	148	81877	27
34	70539	149	29461	86366	150	13634	02318	151	97682	18392	152	81608	26
35	70802	153	29198	86631	154	13369	02585	156	97415	18661	157	81339	25
36	71065	158	28935	86896	159	13104	02852	160	97148	18930	161	81070	24
37	71328	162	28672	87160	163	12840	03119	165	96881	19199	166	80801	23
38	71590	167	28410	87425	168	12575	03386	169	96614	19468	170	80532	22
39	71853	171	28147	87690	172	12310	03653	174	96347	19737	175	80263	21
40	72116	175	27884	87955	177	12045	03920	178	96080	20006	179	79994	20
41	72379	180	27621	88220	181	11780	04187	182	95813	20275	184	79725	19
42	72642	184	27358	88486	185	11514	04454	187	95546	20544	188	79456	18
43	72905	189	27095	88751	189	11249	04722	191	95278	20813	193	79187	17
44	73168	193	26832	89016	194	10984	04989	196	95011	21082	197	78918	16
45	73431	197	26569	89281	199	10719	05256	200	94744	21351	202	78649	15
46	73694	202	26306	89546	203	10454	05523	205	94477	21621	206	78379	14
47	73957	206	26043	89812	207	10188	05791	209	94209	21890	211	78110	13
48	74221	210	25779	90077	212	09923	06058	214	93942	22159	215	77841	12
49	74484	215	25516	90342	216	09658	06325	218	93675	22429	220	77571	11
50	74747	219	25253	90608	221	09392	06593	223	93407	22698	224	77302	10
51	75010	224	24990	90873	225	09127	06860	227	93140	22967	229	77033	9
52	75274	228	24726	91138	230	08862	07128	231	92872	23237	233	76763	8
53	75537	232	24463	91404	234	08596	07395	236	92605	23506	238	76494	7
54	75801	237	24199	91669	239	08331	07663	240	92337	23776	242	76224	6
55	76064	241	23936	91935	243	08065	07930	245	92070	24045	247	75955	5
56	76327	245	23673	92201	247	07799	08198	249	91802	24315	251	75685	4
57	76591	250	23409	92466	252	07534	08466	254	91534	24584	256	75416	3
58	76854	254	23146	92732	256	07268	08733	258	91267	24854	260	75146	2
59	77118	259	22882	92998	260	07002	09001	263	90999	25124	265	74876	1
60	77382	263	22618	93263	265	06737	09269	267	90731	25393	269	74607	0
″ Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	′ ″ Suv.
	115°			114°			113°			112°			

TABLE XXVIII.

Decimal Versed and Suversed Sines.

′	68°			69°			70°			71°			″
″ Vers.	Vers.	Parts for ″	Suvers.	Vers.	Parts for ″	Suvers.	Vers.	Parts for ′	Suvers.	Vers.	Parts for ″	Suvers.	Suv. ″
0	25393	0	74607	41632	0	58368	57980	0	42020	74432	0	25568	60
1	25663	5	74337	41904	5	58096	58253	5	41747	74707	5	25293	59
2	25933	9	74067	42175	9	57825	58527	9	41473	74982	9	25018	58
3	26203	14	73797	42447	14	57553	58800	14	41200	75257	14	24743	57
4	26472	18	73528	42719	18	57281	59073	18	40927	75532	18	24468	56
5	26742	23	73258	42990	23	57010	59347	23	40653	75807	23	24193	55
6	27012	27	72988	43262	27	56738	59620	27	40380	76083	27	23917	54
7	27282	32	72718	43534	32	56466	59894	32	40106	76358	32	23642	53
8	27552	36	72448	43806	36	56194	60167	36	39833	76633	37	23367	52
9	27822	41	72178	44077	41	55923	60441	41	39559	76908	41	23092	51
10	28092	45	71908	44349	46	55651	60715	46	39285	77184	46	22816	50
11	28362	50	71638	44621	50	55379	60988	50	39012	77459	51	22541	49
12	28632	54	71368	44893	54	55107	61262	55	38738	77734	55	22266	48
13	28902	59	71098	45165	59	54835	61536	59	38464	78010	60	21990	47
14	29172	63	70828	45437	63	54563	61809	64	38191	78285	64	21715	46
15	29443	68	70557	45709	68	54291	62083	68	37917	78560	69	21440	45
16	29713	72	70287	45981	73	54019	62357	73	37643	78836	74	21164	44
17	29983	77	70017	46253	77	53747	62631	78	37369	79111	78	20889	43
18	30253	81	69747	46525	82	53475	62905	82	37095	79387	83	20613	42
19	30523	86	69477	46797	87	53203	63179	87	36821	79663	87	20337	41
20	30794	90	69206	47069	91	52931	63452	91	36548	79938	92	20062	40
21	31064	95	68936	47342	96	52658	63726	96	36274	80214	96	19786	39
22	31335	100	68665	47614	100	52386	64000	100	36000	80489	101	19511	38
23	31605	104	68395	47886	105	52114	64274	105	35726	80765	106	19235	37
24	31875	108	68125	48158	109	51842	64548	109	35452	81041	110	18959	36
25	32146	113	67854	48431	114	51569	64822	114	35178	81316	115	18684	35
26	32416	117	67584	48703	118	51297	65097	118	34903	81592	119	18408	34
27	32687	122	67313	48975	123	51025	65371	123	34629	81868	124	18132	33
28	32957	126	67043	49248	127	50752	65645	127	34355	82144	128	17856	32
29	33228	131	66772	49520	132	50480	65919	132	34081	82419	133	17581	31
30	33499	135	66501	49793	136	50207	66193	137	33807	82695	138	17305	30
31	33769	140	66231	50065	141	49935	66467	142	33533	82971	143	17029	29
32	34040	144	65960	50338	145	49662	66742	146	33258	83247	147	16753	28
33	34311	149	65689	50610	150	49390	67016	151	32984	83523	152	16477	27
34	34582	153	65418	50883	155	49117	67290	155	32710	83799	157	16201	26
35	34852	158	65148	51155	159	48845	67564	160	32436	84075	161	15925	25
36	35123	162	64877	51428	164	48572	67839	165	32161	84351	166	15649	24
37	35394	167	64606	51701	168	48299	68113	169	31887	84627	171	15373	23
38	35665	171	64335	51973	173	48027	68388	173	31612	84903	175	15097	22
39	35936	176	64064	52246	177	47754	68662	178	31338	85179	180	14821	21
40	36207	180	63793	52519	182	47481	68937	183	31063	85455	184	14545	20
41	36478	185	63522	52791	186	47209	69211	187	30789	85731	189	14269	19
42	36749	189	63251	53064	191	46936	69486	192	30514	86007	193	13993	18
43	37020	194	62980	53337	195	46663	69760	197	30240	86284	198	13716	17
44	37291	198	62709	53610	200	46390	70035	201	29965	86560	202	13440	16
45	37562	203	62438	53883	205	46117	70309	206	29691	86836	207	13164	15
46	37833	207	62167	54156	209	45844	70584	210	29416	87112	212	12888	14
47	38104	212	61896	54429	214	45571	70859	215	29141	87389	216	12611	13
48	38375	216	61625	54702	218	45298	71133	220	28867	87665	221	12335	12
49	38647	221	61353	54975	223	45025	71408	224	28592	87941	225	12059	11
50	38918	226	61082	55248	228	44752	71683	229	28317	88218	230	11782	10
51	39189	230	60811	55521	232	44479	71958	234	28042	88494	235	11506	9
52	39460	235	60540	55794	237	44206	72232	238	27768	88771	239	11229	8
53	39732	239	60268	56067	241	43933	72507	243	27493	89047	244	10953	7
54	40003	244	59997	56340	246	43660	72782	247	27218	89324	248	10676	6
55	40275	248	59725	56614	250	43386	73057	252	26943	89600	253	10400	5
56	40546	253	59454	56887	255	43113	73332	256	26668	89877	258	10123	4
57	40817	257	59183	57160	260	42840	73607	261	26393	90153	262	09847	3
58	41089	262	58911	57433	264	42567	73882	265	26118	90430	267	09570	2
59	41360	266	58640	57706	268	42294	74157	270	25843	90706	271	09294	1
60	41632	271	58368	57980	273	42020	74432	274	25568	90983	276	09017	0
″ Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	′ ″ Suv.
	111°			110°			109°			108°			

TABLE XXVIII.

Decimal Versed and Suversed Sines.

′	72°			73°			74°			75°			
″ Vers.	Vers.	Parts for ″	Suvers.	Vers.	Parts for ″	Suvers.	Vers.	Parts for ″	Suvers.	Vers.	Parts for ″	Suvers.	″ Suv.
0	90983	0	09017	07628	0	92372	24363	0	75637	41181	0	58819	60
1	91260	5	08740	07906	5	92094	24642	5	75358	41462	5	58538	59
2	91536	9	08464	08185	9	91815	24922	9	75078	41743	9	58257	58
3	91813	14	08187	08463	14	91537	25202	14	74798	42024	14	57976	57
4	92090	18	07910	08741	19	91259	25481	19	74519	42305	19	57695	56
5	92367	23	07633	09019	23	90981	25761	23	74239	42586	23	57414	55
6	92643	28	07357	09298	28	90702	26041	28	73959	42867	28	57133	54
7	92920	32	07080	09576	32	90424	26321	33	73679	43148	33	56852	53
8	93197	37	06803	09854	37	90146	26600	37	73400	43429	37	56571	52
9	93474	42	06526	10133	42	89867	26880	42	73120	43711	42	56289	51
10	93751	46	06249	10411	46	89589	27160	47	72840	43992	47	56008	50
11	94028	51	05972	10690	51	89310	27440	51	72560	44273	52	55727	49
12	94305	55	05695	10968	56	89032	27720	56	72280	44554	56	55446	48
13	94582	60	05418	11247	60	88753	28000	61	72000	44835	61	55165	47
14	94859	65	05141	11525	65	88475	28280	65	71720	45117	66	54883	46
15	95136	69	04864	11804	70	88196	28560	70	71440	45398	70	54602	45
16	95413	74	04587	12082	74	87918	28839	75	71161	45679	75	54321	44
17	95690	78	04310	12361	79	87639	29119	79	70881	45961	80	54039	43
18	95967	83	04033	12639	84	87361	29400	84	70600	46242	84	53758	42
19	96244	88	03756	12918	88	87082	29680	89	70320	46523	89	53477	41
20	96521	92	03479	13197	93	86803	29960	93	70040	46805	94	53195	40
21	96798	97	03202	13476	98	86525	30240	98	69760	47086	98	52914	39
22	97076	102	02924	13754	102	86246	30520	103	69480	47368	103	52632	38
23	97353	106	02647	14033	107	85967	30800	107	69200	47649	108	52351	37
24	97630	111	02370	14312	112	85688	31080	112	68920	47931	113	52069	36
25	97907	116	02093	14590	116	85410	31360	117	68640	48212	117	51788	35
26	98185	120	01815	14869	121	85131	31641	121	68359	48494	122	51506	34
27	98462	125	01538	15148	126	84852	31921	126	68079	48775	127	51225	33
28	98739	130	01261	15427	130	84573	32201	131	67799	49057	131	50943	32
29	99017	134	00983	15706	135	84294	32481	135	67519	49338	136	50662	31
30	99294	139	00706	15985	139	84015	32762	140	67238	49620	141	50380	30
31	99572	143	00428	16264	144	83736	33042	145	66958	49902	146	50098	29
32	99849	148	00151	16542	149	83458	33322	150	66678	50183	150	49817	28
33	00127	153	99873	16821	154	83179	33603	154	66397	50465	155	49535	27
34	00404	157	99596	17100	158	82900	33883	159	66117	50747	160	49253	26
35	00682	162	99318	17379	163	82621	34163	164	65837	51028	165	48972	25
36	00959	167	99041	17658	168	82342	34444	169	65556	51310	169	48690	24
37	01237	171	98763	17938	172	82062	34724	173	65276	51592	174	48408	23
38	01514	176	98486	18217	177	81783	35005	178	64995	51874	179	48126	22
39	01792	181	98208	18496	182	81504	35285	183	64715	52155	183	47845	21
40	02070	185	97930	18775	186	81225	35566	187	64434	52437	188	47563	20
41	02347	190	97653	19054	191	80946	35846	192	64154	52719	193	47281	19
42	02625	195	97375	19333	196	80667	36127	197	63873	53001	198	46999	18
43	02903	199	97097	19612	200	80388	36407	201	63593	53283	202	46717	17
44	03181	204	96819	19892	205	80108	36688	206	63312	53565	207	46435	16
45	03458	208	96542	20171	210	79829	36969	211	63031	53847	212	46153	15
46	03736	213	96264	20450	214	79550	37249	215	62751	54129	216	45871	14
47	04014	218	95986	20730	219	79270	37530	220	62470	54411	221	45589	13
48	04292	222	95708	21009	224	78991	37811	225	62189	54693	225	45307	12
49	04570	227	95430	21288	228	78712	38091	230	61909	54975	230	45025	11
50	04848	231	95152	21568	233	78432	38372	234	61628	55257	235	44743	10
51	05126	236	94874	21847	238	78153	38653	239	61347	55539	240	44461	9
52	05404	241	94596	22126	242	77874	38934	244	61066	55821	245	44179	8
53	05682	245	94318	22406	247	77594	39215	248	60785	56103	249	43897	7
54	05960	250	94040	22685	252	77315	39495	253	60505	56385	254	43615	6
55	06238	254	93762	22965	256	77035	39776	258	60224	56667	259	43333	5
56	06516	259	93484	23244	261	76756	40057	262	59943	56949	263	43051	4
57	06794	264	93206	23524	266	76476	40338	267	59662	57231	268	42769	3
58	07072	268	92928	23803	270	76197	40619	272	59381	57514	273	42486	2
59	07350	273	92650	24083	275	75917	40900	276	59100	57796	277	42204	1
60	07628	277	92372	24363	279	75637	41181	281	58819	58078	282	41922	0
″ Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	′ ″ Suv.
	107°			106°			105°			104°			

TABLE XXVIII.

Decimal Versed and Suversed Sines.

′	76°			77°			78°			79°			
″ Vers.	Vers.	Parts for ″	Suvers.	Vers.	Parts for ″	Suvers.	Vers.	Parts for ″	Suvers.	Vers.	Parts for ″	Suvers.	″ Suv.
0	58078	0	41922	75049	0	24951	92088	0	07912	09191	0	90809	60
1	58360	5	41640	75332	5	24668	92373	5	07627	09477	5	90523	59
2	58643	9	41357	75616	9	24384	92657	9	07343	09762	10	90238	58
3	58925	14	41075	75899	14	24101	92942	14	07058	10048	14	89952	57
4	59207	19	40793	76183	19	23817	93227	19	06773	10333	19	89667	56
5	59490	24	40510	76466	24	23534	93511	24	06489	10619	24	89381	55
6	59772	28	40228	76750	28	23250	93796	28	06204	10905	29	89095	54
7	60054	33	39946	77033	33	22967	94080	33	05920	11190	33	88810	53
8	60337	38	39663	77317	38	22683	94365	38	05635	11476	38	88524	52
9	60619	43	39381	77601	43	22399	94650	43	05350	11761	43	88239	51
10	60902	47	39098	77884	47	22116	94934	47	05066	12047	48	87953	50
11	61184	52	38816	78168	52	21832	95219	52	04781	12333	52	87667	49
12	61466	57	38534	78451	57	21549	95504	57	04496	12619	57	87381	48
13	61749	61	38251	78735	62	21265	95789	62	04211	12904	62	87096	47
14	62032	66	37968	79019	66	20981	96073	66	03927	13190	67	86810	46
15	62314	71	37686	79303	71	20697	96358	71	03642	13476	71	86524	45
16	62597	75	37403	79586	76	20414	96643	76	03357	13762	76	86238	44
17	62879	80	37121	79870	81	20130	96928	81	03072	14048	81	85952	43
18	63162	85	36838	80154	85	19846	97213	85	02787	14333	86	85667	42
19	63444	90	36556	80438	90	19562	97498	90	02502	14619	91	85381	41
20	63727	94	36273	80721	95	19279	97782	95	02218	14905	95	85095	40
21	64010	99	35990	81005	100	18995	98067	100	01933	15191	100	84809	39
22	64292	104	35708	81289	104	18711	98352	104	01648	15477	105	84523	38
23	64575	109	35425	81573	109	18427	98637	109	01363	15763	110	84237	37
24	64858	113	35142	81857	114	18143	98922	114	01078	16049	115	83951	36
25	65141	118	34859	82141	119	17859	99207	119	00793	16335	119	83665	35
26	65423	123	34577	82425	123	17575	99492	123	00508	16620	124	83380	34
27	65706	127	34294	82708	128	17292	99777	128	00223	16906	129	83094	33
28	65989	132	34011	82992	133	17008	00062	133	99938	17192	134	82808	32
29	66272	137	33728	83276	138	16724	00347	138	99653	17478	138	82522	31
30	66555	141	33445	83560	142	16440	00632	143	99368	17764	143	82236	30
31	66837	146	33163	83844	147	16156	00917	147	99083	18050	148	81950	29
32	67120	151	32880	84128	152	15872	01202	152	98798	18336	153	81664	28
33	67403	156	32597	84412	157	15588	01487	157	98513	18623	157	81377	27
34	67686	161	32314	84696	161	15304	01772	162	98228	18909	162	81091	26
35	67969	165	32031	84981	166	15019	02057	166	97943	19195	167	80805	25
36	68252	170	31748	85265	171	14735	02343	171	97657	19481	172	80519	24
37	68535	175	31465	85549	176	14451	02628	176	97372	19767	176	80233	23
38	68818	179	31182	85833	180	14167	02913	181	97087	20053	181	79947	22
39	69101	184	30899	86117	185	13883	03198	185	96802	20339	186	79661	21
40	69384	189	30616	86401	190	13599	03483	190	96517	20625	191	79375	20
41	69667	194	30333	86685	195	13315	03769	195	96231	20912	195	79088	19
42	69950	198	30050	86970	199	13030	04054	200	95946	21198	200	78802	18
43	70233	203	29767	87254	204	12746	04339	205	95661	21484	205	78516	17
44	70516	208	29484	87538	209	12462	04624	209	95376	21770	210	78230	16
45	70800	213	29200	87822	213	12178	04910	214	95090	22056	214	77944	15
46	71088	217	28917	88107	218	11893	05195	219	94805	22343	219	77657	14
47	71366	222	28634	88391	223	11609	05480	224	94520	22629	224	77371	13
48	71649	227	28351	88675	228	11325	05766	228	94234	22915	229	77085	12
49	71932	232	28068	88960	232	11040	06051	233	93949	23202	234	76798	11
50	72216	236	27784	89244	237	10756	06336	238	93664	23488	238	76512	10
51	72499	241	27501	89528	242	10472	06622	243	93378	23774	243	76226	9
52	72782	246	27218	89813	247	10187	06907	247	93093	24060	248	75940	8
53	73065	250	26935	90097	251	09903	07193	252	92807	24347	253	75653	7
54	73349	255	26651	90381	256	09619	07478	257	92522	24633	257	75367	6
55	73632	260	26368	90666	261	09334	07763	262	92237	24920	262	75080	5
56	73915	265	26085	90950	266	09050	08049	267	91951	25206	267	74794	4
57	74199	269	25801	91235	270	08765	08334	272	91666	25492	272	74508	3
58	74482	274	25518	91519	275	08481	08620	276	91380	25779	276	74221	2
59	74765	279	25235	91804	280	08196	08905	281	91095	26065	281	73935	1
60	75049	283	24951	92088	284	07912	09191	285	90809	26352	286	73648	0
″ Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	′ ″ Suv.
	103°			102°			101°			100°			

TABLE XXVIII.

Decimal Versed and Suversed Sines.

′	80°			81°			82°			83°			
″ Vers.	Vers.	Parts for ″	Suvers.	Vers.	Parts for ″	Suvers.	Vers.	Parts for ″	Suvers.	Vers.	Parts for ″	Suvers.	″ Suv.
0	26352	0	73648	43565	0	56435	60827	0	39173	78131	0	21869	60
1	26638	5	73362	43853	5	56147	61115	5	38885	78419	5	21581	59
2	26925	10	73075	44140	10	55860	61403	10	38597	78708	10	21292	58
3	27211	14	72789	44427	14	55573	61691	14	38309	78997	14	21003	57
4	27498	19	72502	44715	19	55285	61979	19	38021	79286	19	20714	56
5	27784	24	72216	45002	24	54998	62267	24	37733	79574	24	20426	55
6	28071	29	71929	45290	29	54710	62555	29	37445	79863	29	20137	54
7	28358	33	71642	45577	33	54423	62844	34	37156	80152	34	19848	53
8	28644	38	71356	45864	38	54136	63132	38	36868	80441	39	19559	52
9	28931	43	71069	46152	43	53848	63420	43	36580	80730	43	19270	51
10	29217	48	70783	46439	48	53561	63708	48	36292	81018	48	18982	50
11	29504	52	70496	46727	53	53273	63996	53	36004	81307	53	18693	49
12	29790	57	70210	47014	57	52986	64284	58	35716	81596	58	18404	48
13	30077	62	69923	47302	62	52698	64573	62	35427	81885	63	18115	47
14	30364	67	69636	47589	67	52411	64861	67	35139	82174	67	17826	46
15	30650	72	69350	47877	72	52123	65149	72	34851	82463	72	17537	45
16	30937	76	69063	48164	77	51836	65437	77	34563	82751	77	17249	44
17	31224	81	68776	48452	81	51548	65726	82	34274	83040	82	16960	43
18	31511	86	68489	48739	86	51261	66014	86	33986	83329	87	16671	42
19	31797	91	68203	49027	91	50973	66302	91	33698	83618	91	16382	41
20	32084	96	67916	49314	96	50686	66590	96	33410	83907	96	16093	40
21	32371	100	67629	49602	101	50398	66879	101	33121	84196	101	15804	39
22	32658	105	67342	49889	106	50111	67167	106	32833	84485	106	15515	38
23	32944	110	67056	50177	111	49823	67455	110	32545	84774	111	15226	37
24	33231	115	66769	50465	116	49535	67744	115	32256	85063	116	14937	36
25	33518	119	66482	50752	120	49248	68032	120	31968	85352	120	14648	35
26	33805	124	66195	51040	125	48960	68320	125	31680	85641	125	14359	34
27	34092	129	65908	51328	130	48672	68609	130	31391	85930	130	14070	33
28	34379	134	65621	51615	135	48385	68897	134	31103	86219	135	13781	32
29	34665	138	65335	51903	140	48097	69185	139	30815	86508	140	13492	31
30	34952	143	65048	52191	144	47809	69474	144	30526	86797	144	13203	30
31	35239	148	64761	52478	149	47522	69762	149	30238	87086	149	12914	29
32	35526	153	64474	52766	153	47234	70051	154	29949	87375	154	12625	28
33	35813	158	64187	53054	158	46946	70339	159	29661	87664	159	12336	27
34	36100	163	63900	53341	163	46659	70627	163	29373	87953	164	12047	26
35	36387	167	63613	53629	168	46371	70916	168	29084	88242	169	11758	25
36	36674	172	63326	53917	172	46083	71204	173	28796	88531	174	11469	24
37	36961	177	63039	54205	177	45795	71493	178	28507	88820	179	11180	23
38	37248	182	62752	54492	182	45508	71781	183	28219	89109	184	10891	22
39	37535	187	62465	54780	187	45220	72070	187	27930	89398	189	10602	21
40	37822	191	62178	55068	192	44932	72358	192	27642	89687	193	10313	20
41	38109	196	61891	55356	196	44644	72647	197	27353	89977	198	10023	19
42	38396	201	61604	55644	201	44356	72935	202	27065	90266	203	09734	18
43	38683	206	61317	55932	206	44068	73224	207	26776	90555	208	09445	17
44	38970	210	61030	56219	211	43781	73512	212	26488	90844	212	09156	16
45	39257	215	60743	56507	215	43493	73801	216	26199	91133	217	08867	15
46	39544	220	60456	56795	220	43205	74090	221	25910	91422	222	08578	14
47	39832	225	60168	57083	225	42917	74378	226	25622	91711	227	08289	13
48	40119	230	59881	57371	230	42629	74667	231	25333	92001	231	07999	12
49	40406	234	59594	57659	235	42341	74955	236	25045	92290	236	07710	11
50	40693	239	59307	57947	240	42053	75244	240	24756	92579	241	07421	10
51	40980	244	59020	58235	244	41765	75533	245	24467	92868	246	07132	9
52	41267	249	58733	58523	249	41477	75821	250	24179	93158	250	06842	8
53	41555	254	58445	58811	254	41189	76110	255	23890	93447	255	06553	7
54	41842	258	58158	59099	259	40901	76398	260	23602	93736	260	06264	6
55	42129	263	57871	59387	264	40613	76687	264	23313	94025	265	05975	5
56	42416	268	57584	59675	268	40325	76976	269	23024	94314	270	05686	4
57	42704	273	57296	59963	273	40037	77264	274	22736	94604	275	05396	3
58	42991	277	57009	60251	278	39749	77553	279	22447	94893	279	05107	2
59	43278	282	56722	60539	283	39461	77842	284	22158	95182	284	04818	1
60	43565	287	56435	60827	287	39173	78131	288	21869	95471	289	04529	0
″ Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	′ ″ Suv.
	99°			98°			97°			96°			

TABLE XXVIII.

Decimal Versed and Suversed Sines.

′ / ″ Vers.	84° Vers.	84° Parts for ″	84° Suvers.	85° Vers.	85° Parts for ″	85° Suvers.	86° Vers.	86° Parts for ″	86° Suvers.	87° Vers.	87° Parts for ″	87° Suvers.	′ / ″ Suv.
0	95471	0	04529	12844	0	87156	30243	0	69757	47664	0	52336	60
1	95761	5	04239	13134	5	86866	30534	5	69466	47954	5	52046	59
2	96050	10	03950	13424	10	86576	30824	10	69176	48245	10	51755	58
3	96339	15	03661	13714	15	86286	31114	15	68886	48535	15	51465	57
4	96629	19	03371	14003	19	85997	31404	19	68596	48826	19	51174	56
5	96918	24	03082	14293	24	85707	31694	24	68306	49116	24	50884	55
6	97208	29	02792	14583	29	85417	31985	29	68015	49407	29	50593	54
7	97497	34	02503	14873	34	85127	32275	34	67725	49698	34	50302	53
8	97786	39	02214	15163	39	84837	32565	39	67435	49988	39	50012	52
9	98075	44	01925	15453	44	84547	32855	44	67145	50279	44	49721	51
10	98365	48	01635	15742	48	84258	33146	48	66854	50569	48	49431	50
11	98654	53	01346	16032	53	83968	33436	53	66564	50860	53	49140	49
12	98944	58	01056	16322	58	83678	33726	58	66274	51150	58	48850	48
13	99233	63	00767	16612	63	83388	34016	63	65984	51441	63	48559	47
14	99522	68	00478	16902	68	83098	34307	68	65693	51731	68	48269	46
15	99812	73	00188	17192	73	82808	34597	73	65403	52022	73	47978	45
16	00101	77	99899	17482	77	82518	34887	77	65113	52312	77	47688	44
17	00391	82	99609	17772	82	82228	35177	82	64823	52603	82	47397	43
18	00680	87	99320	18061	87	81939	35468	87	64532	52893	87	47107	42
19	00970	92	99030	18351	92	81649	35758	92	64242	53184	92	46816	41
20	01259	97	98741	18641	97	81359	36048	97	63952	53475	97	46525	40
21	01549	102	98451	18931	102	81069	36339	102	63661	53765	102	46235	39
22	01838	107	98162	19221	107	80779	36629	106	63371	54056	106	45944	38
23	02128	112	97872	19511	112	80489	36919	111	63081	54346	111	45654	37
24	02417	116	97583	19801	116	80199	37209	116	62791	54637	116	45363	36
25	02707	121	97293	20091	121	79909	37500	121	62500	54928	121	45072	35
26	02996	126	97004	20381	126	79619	37790	126	62210	55218	126	44782	34
27	03286	131	96714	20671	131	79329	38080	131	61920	55509	131	44491	33
28	03575	136	96425	20961	136	79039	38371	136	61629	55799	136	44201	32
29	03865	141	96135	21251	141	78749	38661	140	61339	56090	140	43910	31
30	04154	145	95846	21541	145	78459	38951	145	61049	56381	145	43619	30
31	04444	150	95556	21831	150	78169	39242	150	60758	56671	150	43329	29
32	04733	155	95267	22121	155	77879	39532	155	60468	56962	155	43038	28
33	05023	160	94977	22411	160	77589	39822	160	60178	57252	160	42748	27
34	05312	164	94688	22701	164	77299	40113	165	59887	57543	165	42457	26
35	05602	169	94398	22991	169	77009	40403	169	59597	57834	169	42166	25
36	05892	174	94108	23281	174	76719	40694	174	59306	58124	174	41876	24
37	06181	179	93819	23571	179	76429	40984	179	59016	58415	179	41585	23
38	06471	184	93529	23861	184	76139	41274	184	58726	58706	184	41294	22
39	06760	189	93240	24151	189	75849	41565	189	58435	58996	189	41004	21
40	07050	193	92950	24441	193	75559	41855	194	58145	59287	194	40713	20
41	07340	198	92660	24731	198	75269	42146	198	57854	59578	198	40422	19
42	07629	203	92371	25021	203	74979	42436	203	57564	59868	203	40132	18
43	07919	208	92081	25311	208	74689	42726	208	57274	60159	208	39841	17
44	08209	213	91791	25601	213	74399	43017	213	56983	60449	213	39551	16
45	08498	218	91502	25891	218	74109	43307	218	56693	60740	218	39260	15
46	08788	222	91212	26182	222	73818	43598	223	56402	61031	223	38969	14
47	09078	227	90922	26472	227	73528	43888	227	56112	61321	227	38679	13
48	09367	232	90633	26762	232	73238	44178	232	55822	61612	232	38388	12
49	09657	237	90343	27052	237	72948	44469	237	55531	61903	237	38097	11
50	09947	242	90053	27342	242	72658	44759	242	55241	62193	242	37807	10
51	10236	247	89764	27632	247	72368	45050	247	54950	62484	247	37516	9
52	10526	252	89474	27922	252	72078	45340	252	54660	62775	252	37225	8
53	10816	257	89184	28212	257	71788	45631	257	54369	63066	257	36934	7
54	11106	261	88894	28503	261	71497	45921	261	54079	63356	261	36644	6
55	11395	266	88605	28793	266	71207	46212	266	53788	63647	266	36353	5
56	11685	271	88315	29083	271	70917	46502	271	53498	63938	271	36062	4
57	11975	276	88025	29373	276	70627	46793	276	53207	64228	276	35772	3
58	12265	281	87735	29663	281	70337	47083	281	52917	64519	281	35481	2
59	12554	285	87446	29953	285	70047	47374	286	52626	64810	286	35190	1
60	12844	290	87156	30243	290	69757	47664	290	52336	65101	290	34899	0
″ Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	Suvers.	Parts for ″	Vers.	′ / ″ Suv.
	95°			94°			93°			92°			

TABLE XXVIII.

Decimal Versed and Suversed Sines.

′ / ″ Vers.	88° Vers.	88° Parts for ″	88° Suvers.	89° Vers.	89° Parts for ″	89° Suvers.	′ / ″ Suv.
0	65101	0	34899	82548	0	17452	60
1	65391	5	34609	82838	5	17162	59
2	65682	10	34318	83129	10	16871	58
3	65973	15	34027	83420	15	16580	57
4	66263	19	33737	83711	19	16289	56
5	66554	24	33446	84002	24	15998	55
6	66845	29	33155	84293	29	15707	54
7	67136	34	32864	84583	34	15417	53
8	67426	39	32574	84874	39	15126	52
9	67717	44	32283	85165	44	14835	51
10	68008	48	31992	85456	49	14544	50
11	68299	53	31701	85747	53	14253	49
12	68589	58	31411	86038	58	13962	48
13	68880	63	31120	86329	63	13671	47
14	69171	68	30829	86619	68	13381	46
15	69461	73	30539	86910	73	13090	45
16	69752	77	30248	87201	78	12799	44
17	70043	82	29957	87492	83	12508	43
18	70334	87	29666	87783	87	12217	42
19	70624	92	29376	88074	92	11926	41
20	70915	97	29085	88365	97	11635	40
21	71206	102	28794	88656	102	11344	39
22	71497	106	28503	88946	107	11054	38
23	71788	111	28212	89237	112	10763	37
24	72078	116	27922	89528	116	10472	36
25	72369	121	27631	89819	121	10181	35
26	72660	126	27340	90110	126	09890	34
27	72951	131	27049	90401	131	09599	33
28	73241	136	26759	90692	136	09308	32
29	73532	140	26468	90983	141	09017	31
30	73823	145	26177	91274	145	08726	30
31	74114	150	25886	91564	150	08436	29
32	74405	155	25595	91855	155	08145	28
33	74695	160	25305	92146	160	07854	27
34	74986	165	25014	92437	165	07563	26
35	75277	170	24723	92728	170	07272	25
36	75568	175	24432	93019	175	06981	24
37	75859	179	24141	93310	179	06690	23
38	76149	184	23851	93600	184	06400	22
39	76440	189	23560	93891	189	06109	21
40	76731	194	23269	94182	194	05818	20
41	77022	199	22978	94473	199	05527	19
42	77313	204	22687	94764	204	05236	18
43	77603	209	22397	95055	209	04945	17
44	77894	213	22106	95346	213	04654	16
45	78185	218	21815	95637	218	04363	15
46	78476	223	21524	95928	223	04072	14
47	78767	228	21233	96218	228	03782	13
48	79058	233	20942	96509	233	03491	12
49	79348	238	20652	96800	238	03200	11
50	79639	243	20361	97091	243	02909	10
51	79930	247	20070	97382	247	02618	9
52	80221	252	19779	97673	252	02327	8
53	80512	257	19488	97964	257	02036	7
54	80803	262	19197	98255	262	01745	6
55	81093	267	18907	98546	267	01454	5
56	81384	272	18616	98836	272	01164	4
57	81675	276	18325	99127	276	00873	3
58	81966	281	18034	99418	281	00582	2
59	82257	286	17743	99709	286	00291	1
60	82548	291	17452	00000	291	00000	0

″ Vers.	91° Suvers.	91° Parts for ″	91° Vers.	90° Suvers.	90° Parts for ″	90° Vers.	′ / ″ Suv.

TABLE XXIX.

Proportional Logarithms.

s.	h. m. 0° 0′	h. m. 0° 1′	h. m. 0° 2′	h. m. 0° 3′	h. m. 0° 4′	h. m. 0° 5′	h. m. 0° 6′	h. m. 0° 7′	h. m. 0° 8′
0		2.2553	1.9542	1.7782	1.6532	1.5563	1.4771	1.4102	1.3522
1	4.0334	2.2481	1.9506	1.7757	1.6514	1.5549	1.4759	1.4091	1.3513
2	3.7324	2.2410	1.9471	1.7734	1.6496	1.5534	1.4747	1.4081	1.3504
3	3.5563	2.2341	1.9435	1.7710	1.6478	1.5520	1.4735	1.4071	1.3495
4	3.4314	2.2272	1.9400	1.7686	1.6460	1.5505	1.4723	1.4061	1.3486
5	3.3345	2.2205	1.9365	1.7663	1.6443	1.5491	1.4711	1.4050	1.3477
6	3.2553	2.2139	1.9331	1.7639	1.6425	1.5477	1.4699	1.4040	1.3468
7	3.1883	2.2073	1.9296	1.7616	1.6407	1.5463	1.4688	1.4030	1.3459
8	3.1303	2.2009	1.9262	1.7593	1.6390	1.5449	1.4676	1.4020	1.3450
9	3.0792	2.1946	1.9228	1.7570	1.6372	1.5435	1.4664	1.4010	1.3441
10	3.0334	2.1883	1.9195	1.7547	1.6355	1.5421	1.4652	1.4000	1.3432
11	2.9920	2.1822	1.9162	1.7524	1.6337	1.5407	1.4640	1.3989	1.3423
12	2.9542	2.1761	1.9128	1.7501	1.6320	1.5393	1.4629	1.3979	1.3415
13	2.9195	2.1701	1.9096	1.7479	1.6303	1.5379	1.4617	1.3969	1.3406
14	2.8873	2.1642	1.9063	1.7456	1.6286	1.5365	1.4605	1.3959	1.3397
15	2.8573	2.1584	1.9031	1.7434	1.6269	1.5351	1.4594	1.3949	1.3388
16	2.8293	2.1526	1.8999	1.7412	1.6252	1.5337	1.4582	1.3939	1.3379
17	2.8030	2.1469	1.8967	1.7390	1.6235	1.5324	1.4571	1.3929	1.3371
18	2.7782	2.1413	1.8935	1.7368	1.6218	1.5310	1.4559	1.3919	1.3362
19	2.7547	2.1358	1.8904	1.7346	1.6201	1.5296	1.4548	1.3910	1.3353
20	2.7324	2.1303	1.8873	1.7324	1.6184	1.5283	1.4536	1.3900	1.3344
21	2.7112	2.1249	1.8842	1.7302	1.6168	1.5269	1.4525	1.3890	1.3336
22	2.6910	2.1196	1.8811	1.7281	1.6151	1.5256	1.4514	1.3880	1.3327
23	2.6717	2.1143	1.8781	1.7259	1.6135	1.5242	1.4502	1.3870	1.3319
24	2.6532	2.1091	1.8751	1.7238	1.6118	1.5229	1.4491	1.3860	1.3310
25	2.6355	2.1040	1.8721	1.7217	1.6102	1.5215	1.4480	1.3851	1.3301
26	2.6184	2.0989	1.8691	1.7196	1.6085	1.5202	1.4468	1.3841	1.3293
27	2.6021	2.0939	1.8661	1.7175	1.6069	1.5189	1.4457	1.3831	1.3284
28	2.5863	2.0889	1.8632	1.7154	1.6053	1.5175	1.4446	1.3821	1.3276
29	2.5710	2.0840	1.8602	1.7133	1.6037	1.5162	1.4435	1.3812	1.3267
30	2.5563	2.0792	1.8573	1.7112	1.6021	1.5149	1.4424	1.3802	1.3259
31	2.5421	2.0744	1.8544	1.7091	1.6004	1.5136	1.4412	1.3792	1.3250
32	2.5283	2.0696	1.8516	1.7071	1.5988	1.5123	1.4401	1.3783	1.3241
33	2.5149	2.0649	1.8487	1.7050	1.5973	1.5110	1.4390	1.3773	1.3233
34	2.5019	2.0603	1.8459	1.7030	1.5957	1.5097	1.4379	1.3764	1.3225
35	2.4894	2.0557	1.8431	1.7010	1.5941	1.5084	1.4368	1.3754	1.3216
36	2.4771	2.0512	1.8403	1.6990	1.5925	1.5071	1.4357	1.3745	1.3208
37	2.4652	2.0467	1.8375	1.6970	1.5909	1.5058	1.4346	1.3735	1.3199
38	2.4536	2.0422	1.8348	1.6950	1.5894	1.5045	1.4335	1.3726	1.3191
39	2.4424	2.0378	1.8320	1.6930	1.5878	1.5032	1.4325	1.3716	1.3183
40	2.4314	2.0334	1.8293	1.6910	1.5863	1.5019	1.4314	1.3707	1.3174
41	2.4206	2.0291	1.8266	1.6890	1.5847	1.5007	1.4303	1.3697	1.3166
42	2.4102	2.0248	1.8239	1.6871	1.5832	1.4994	1.4292	1.3688	1.3158
43	2.4000	2.0206	1.8212	1.6851	1.5816	1.4981	1.4281	1.3678	1.3149
44	2.3900	2.0164	1.8186	1.6832	1.5801	1.4969	1.4270	1.3669	1.3141
45	2.3802	2.0122	1.8159	1.6812	1.5786	1.4956	1.4260	1.3660	1.3133
46	2.3707	2.0081	1.8133	1.6793	1.5771	1.4943	1.4249	1.3650	1.3124
47	2.3613	2.0040	1.8107	1.6774	1.5755	1.4931	1.4238	1.3641	1.3116
48	2.3522	2.0000	1.8081	1.6755	1.5740	1.4918	1.4228	1.3632	1.3108
49	2.3432	1.9960	1.8055	1.6736	1.5725	1.4906	1.4217	1.3622	1.3100
50	2.3345	1.9920	1.8030	1.6717	1.5710	1.4894	1.4206	1.3613	1.3091
51	2.3259	1.9881	1.8004	1.6698	1.5695	1.4881	1.4196	1.3604	1.3083
52	2.3174	1.9842	1.7979	1.6679	1.5680	1.4869	1.4185	1.3595	1.3075
53	2.3091	1.9803	1.7954	1.6661	1.5666	1.4856	1.4175	1.3586	1.3067
54	2.3010	1.9765	1.7929	1.6642	1.5651	1.4844	1.4164	1.3576	1.3059
55	2.2931	1.9727	1.7904	1.6624	1.5636	1.4832	1.4154	1.3567	1.3051
56	2.2852	1.9690	1.7879	1.6605	1.5621	1.4820	1.4143	1.3558	1.3043
57	2.2775	1.9652	1.7855	1.6587	1.5607	1.4808	1.4133	1.3549	1.3034
58	2.2700	1.9615	1.7830	1.6568	1.5592	1.4795	1.4122	1.3540	1.3026
59	2.2626	1.9579	1.7806	1.6550	1.5577	1.4783	1.4112	1.3531	1.3018

TABLE XXIX.

Proportional Logarithms.

s.	h. m. 0° 9′	h. m. 0° 10′	h. m. 0° 11′	h. m. 0° 12′	h. m. 0° 13′	h. m. 0° 14′	h. m. 0° 15′	h. m. 0° 16′	h. m. 0° 17′
0	1.3010	1.2553	1.2139	1.1761	1.1413	1.1091	1.0792	1.0512	1.0248
1	1.3002	1.2545	1.2132	1.1755	1.1408	1.1086	1.0787	1.0507	1.0244
2	1.2994	1.2538	1.2126	1.1749	1.1402	1.1081	1.0782	1.0502	1.0240
3	1.2986	1.2531	1.2119	1.1743	1.1397	1.1076	1.0777	1.0498	1.0235
4	1.2978	1.2524	1.2113	1.1737	1.1391	1.1071	1.0773	1.0493	1.0231
5	1.2970	1.2517	1.2106	1.1731	1.1385	1.1066	1.0768	1.0489	1.0227
6	1.2962	1.2510	1.2099	1.1725	1.1380	1.1061	1.0763	1.0484	1.0223
7	1.2954	1.2502	1.2093	1.1719	1.1374	1.1055	1.0758	1.0480	1.0218
8	1.2946	1.2495	1.2086	1.1713	1.1369	1.1050	1.0753	1.0475	1.0214
9	1.2939	1.2488	1.2080	1.1707	1.1363	1.1045	1.0749	1.0471	1.0210
10	1.2931	1.2481	1.2073	1.1701	1.1358	1.1040	1.0744	1.0467	1.0206
11	1.2923	1.2474	1.2067	1.1695	1.1352	1.1035	1.0739	1.0462	1.0202
12	1.2915	1.2467	1.2061	1.1689	1.1347	1.1030	1.0734	1.0458	1.0197
13	1.2907	1.2460	1.2054	1.1683	1.1341	1.1025	1.0729	1.0453	1.0193
14	1.2899	1.2453	1.2048	1.1677	1.1336	1.1020	1.0725	1.0449	1.0189
15	1.2891	1.2445	1.2041	1.1671	1.1331	1.1015	1.0720	1.0444	1.0185
16	1.2883	1.2438	1.2035	1.1665	1.1325	1.1009	1.0715	1.0440	1.0181
17	1.2876	1.2431	1.2028	1.1660	1.1320	1.1004	1.0710	1.0435	1.0176
18	1.2868	1.2424	1.2022	1.1654	1.1314	1.0999	1.0706	1.0431	1.0172
19	1.2860	1.2417	1.2015	1.1648	1.1309	1.0994	1.0701	1.0426	1.0168
20	1.2852	1.2410	1.2009	1.1642	1.1303	1.0989	1.0696	1.0422	1.0164
21	1.2845	1.2403	1.2003	1.1636	1.1298	1.0984	1.0692	1.0418	1.0160
22	1.2837	1.2396	1.1996	1.1630	1.1292	1.0979	1.0687	1.0413	1.0156
23	1.2829	1.2389	1.1990	1.1624	1.1287	1.0974	1.0682	1.0409	1.0151
24	1.2821	1.2382	1.1984	1.1619	1.1282	1.0969	1.0678	1.0404	1.0147
25	1.2814	1.2375	1.1977	1.1613	1.1276	1.0964	1.0673	1.0400	1.0143
26	1.2806	1.2368	1.1971	1.1607	1.1271	1.0959	1.0668	1.0395	1.0139
27	1.2798	1.2362	1.1965	1.1601	1.1266	1.0954	1.0663	1.0391	1.0135
28	1.2791	1.2355	1.1958	1.1595	1.1260	1.0949	1.0659	1.0387	1.0131
29	1.2783	1.2348	1.1952	1.1589	1.1255	1.0944	1.0654	1.0382	1.0126
30	1.2775	1.2341	1.1946	1.1584	1.1249	1.0939	1.0649	1.0378	1.0122
31	1.2768	1.2334	1.1939	1.1578	1.1244	1.0934	1.0645	1.0373	1.0118
32	1.2760	1.2327	1.1933	1.1572	1.1239	1.0929	1.0640	1.0369	1.0114
33	1.2753	1.2320	1.1927	1.1566	1.1233	1.0924	1.0635	1.0365	1.0110
34	1.2745	1.2313	1.1921	1.1560	1.1228	1.0919	1.0631	1.0360	1.0106
35	1.2738	1.2306	1.1914	1.1555	1.1223	1.0914	1.0626	1.0356	1.0102
36	1.2730	1.2300	1.1908	1.1549	1.1217	1.0909	1.0621	1.0352	1.0098
37	1.2722	1.2293	1.1902	1.1543	1.1212	1.0904	1.0617	1.0347	1.0093
38	1.2715	1.2286	1.1896	1.1537	1.1207	1.0899	1.0612	1.0343	1.0089
39	1.2707	1.2279	1.1889	1.1532	1.1201	1.0894	1.0608	1.0339	1.0085
40	1.2700	1.2272	1.1883	1.1526	1.1196	1.0889	1.0603	1.0334	1.0081
41	1.2692	1.2266	1.1877	1.1520	1.1191	1.0884	1.0598	1.0330	1.0077
42	1.2685	1.2259	1.1871	1.1515	1.1186	1.0880	1.0594	1.0326	1.0073
43	1.2678	1.2252	1.1865	1.1509	1.1180	1.0875	1.0589	1.0321	1.0069
44	1.2670	1.2245	1.1858	1.1503	1.1175	1.0870	1.0584	1.0317	1.0065
45	1.2663	1.2239	1.1852	1.1498	1.1170	1.0865	1.0580	1.0313	1.0061
46	1.2655	1.2232	1.1846	1.1492	1.1164	1.0860	1.0575	1.0308	1.0057
47	1.2648	1.2225	1.1840	1.1486	1.1159	1.0855	1.0571	1.0304	1.0053
48	1.2640	1.2218	1.1834	1.1481	1.1154	1.0850	1.0566	1.0300	1.0049
49	1.2633	1.2212	1.1828	1.1475	1.1149	1.0845	1.0562	1.0295	1.0044
50	1.2626	1.2205	1.1822	1.1469	1.1143	1.0840	1.0557	1.0291	1.0040
51	1.2618	1.2198	1.1816	1.1464	1.1138	1.0835	1.0552	1.0287	1.0036
52	1.2611	1.2192	1.1809	1.1458	1.1133	1.0831	1.0548	1.0282	1.0032
53	1.2604	1.2185	1.1803	1.1452	1.1128	1.0826	1.0543	1.0278	1.0028
54	1.2596	1.2178	1.1797	1.1447	1.1123	1.0821	1.0539	1.0274	1.0024
55	1.2589	1.2172	1.1791	1.1441	1.1117	1.0816	1.0534	1.0270	1.0020
56	1.2582	1.2165	1.1785	1.1436	1.1112	1.0811	1.0530	1.0265	1.0016
57	1.2574	1.2159	1.1779	1.1430	1.1107	1.0806	1.0525	1.0261	1.0012
58	1.2567	1.2152	1.1773	1.1424	1.1102	1.0801	1.0521	1.0257	1.0008
59	1.2560	1.2145	1.1767	1.1419	1.1097	1.0797	1.0516	1.0252	1.0004

TABLE XXIX.

Proportional Logarithms.

s. ″	h. m. 0° 18′	h. m. 0°19′	h. m. 0°20′	h. m. 0°21′	h. m. 0°22′	h. m. 0°23′	h. m. 0°24′	h. m. 0°25′	h. m. 0°26′	h. m. 0°27′	h. m. 0°28′	h. m. 0°29′
0	1.0000	9765	9542	9331	9128	8935	8751	8573	8403	8239	8081	7929
1	9996	9761	9539	9327	9125	8932	8748	8570	8400	8236	8079	7926
2	9992	9758	9535	9324	9122	8929	8745	8567	8397	8234	8076	7924
3	9988	9754	9532	9320	9119	8926	8742	8565	8395	8231	8073	7921
4	9984	9750	9528	9317	9115	8923	8739	8562	8392	8228	8071	7919
5	9980	9746	9524	9313	9112	8920	8736	8559	8389	8226	8068	7916
6	9976	9742	9521	9310	9109	8917	8733	8556	8386	8223	8066	7914
7	9972	9739	9517	9306	9105	8913	8730	8553	8383	8220	8063	7911
8	9968	9735	9514	9303	9102	8910	8727	8550	8381	8218	8060	7909
9	9964	9731	9510	9300	9099	8907	8724	8547	8378	8215	8058	7906
10	9960	9727	9506	9296	9096	8904	8721	8544	8375	8212	8055	7904
11	9956	9723	9503	9293	9092	8901	8718	8542	8372	8210	8053	7901
12	9952	9720	9499	9289	9089	8898	8715	8539	8370	8207	8050	7899
13	9948	9716	9496	9286	9086	8895	8712	8536	8367	8204	8048	7896
14	9944	9712	9492	9283	9083	8892	8709	8533	8364	8202	8045	7894
15	9940	9708	9488	9279	9079	8888	8706	8530	8361	8199	8043	7891
16	9936	9705	9485	9276	9076	8885	8703	8527	8359	8196	8040	7889
17	9932	9701	9481	9272	9073	8882	8700	8524	8356	8194	8037	7886
18	9928	9697	9478	9269	9070	8879	8697	8522	8353	8191	8035	7884
19	9924	9693	9474	9265	9066	8876	8694	8519	8350	8188	8032	7882
20	9920	9690	9471	9262	9063	8873	8691	8516	8348	8186	8030	7879
21	9916	9686	9467	9259	9060	8870	8688	8513	8345	8183	8027	7877
22	9912	9682	9464	9255	9057	8867	8685	8510	8342	8180	8025	7874
23	9908	9678	9460	9252	9053	8864	8682	8507	8339	8178	8022	7872
24	9905	9675	9456	9249	9050	8861	8679	8504	8337	8175	8020	7869
25	9901	9671	9453	9245	9047	8857	8676	8501	8334	8173	8017	7867
26	9897	9667	9449	9242	9044	8854	8673	8499	8331	8170	8014	7864
27	9893	9664	9446	9238	9041	8851	8670	8496	8328	8167	8012	7862
28	9889	9660	9442	9235	9037	8848	8667	8493	8326	8165	8009	7859
29	9885	9656	9439	9232	9034	8845	8664	8490	8323	8162	8007	7857
30	9881	9652	9435	9228	9031	8842	8661	8487	8320	8159	8004	7855
31	9877	9649	9432	9225	9028	8839	8658	8484	8317	8157	8002	7852
32	9873	9645	9428	9222	9024	8836	8655	8482	8315	8154	7999	7850
33	9869	9641	9425	9218	9021	8833	8652	8479	8312	8152	7997	7847
34	9865	9638	9421	9215	9018	8830	8649	8476	8309	8149	7994	7845
35	9861	9634	9418	9211	9015	8827	8646	8473	8307	8146	7992	7842
36	9858	9630	9414	9208	9012	8824	8643	8470	8304	8144	7989	7840
37	9854	9626	9410	9205	9008	8820	8640	8467	8301	8141	7986	7837
38	9850	9623	9407	9201	9005	8817	8637	8465	8298	8138	7984	7835
39	9846	9619	9404	9198	9002	8814	8635	8462	8296	8136	7981	7832
40	9842	9615	9400	9195	8999	8811	8632	8459	8293	8133	7979	7830
41	9838	9612	9396	9191	8996	8808	8629	8456	8290	8130	7976	7828
42	9834	9608	9393	9188	8992	8805	8626	8453	8288	8128	7974	7825
43	9830	9604	9389	9185	8989	8802	8623	8451	8285	8125	7971	7823
44	9827	9601	9386	9181	8986	8799	8620	8448	8282	8123	7969	7820
45	9823	9597	9383	9178	8983	8796	8617	8445	8279	8120	7966	7818
46	9819	9593	9379	9175	8980	8793	8614	8442	8277	8117	7964	7815
47	9815	9590	9376	9171	8977	8790	8611	8439	8274	8115	7961	7813
48	9811	9586	9372	9168	8973	8787	8608	8437	8271	8112	7959	7811
49	9807	9582	9369	9165	8970	8784	8605	8434	8269	8110	7956	7808
50	9803	9579	9365	9161	8967	8781	8602	8431	8266	8107	7954	7806
51	9800	9575	9362	9158	8964	8778	8599	8428	8263	8104	7951	7803
52	9796	9571	9358	9155	8961	8775	8596	8425	8261	8102	7949	7801
53	9792	9568	9355	9152	8957	8772	8594	8422	8258	8099	7946	7798
54	9788	9564	9351	9148	8954	8769	8591	8420	8255	8097	7944	7796
55	9784	9561	9348	9145	8951	8766	8588	8417	8252	8094	7941	7794
56	9780	9557	9344	9142	8948	8763	8585	8414	8250	8091	7939	7791
57	9777	9553	9341	9138	8945	8760	8582	8411	8247	8089	7936	7789
58	9773	9550	9337	9135	8942	8757	8579	8409	8244	8086	7934	7786
59	9769	9546	9334	9132	8939	8754	8576	8406	8242	8084	7931	7784

Proportional Logarithms.

s. //	h. m. 0°30′	h. m. 0°31′	h. m. 0°32′	h. m. 0°33′	h. m. 0°34′	h. m. 0°35′	h. m. 0°36′	h. m. 0°37′	h. m. 0°38′	h. m. 0°39′	h. m. 0°40′	h. m. 0°41′
0	7782	7639	7501	7368	7238	7112	6990	6871	6755	6642	6532	6425
1	7779	7637	7499	7365	7236	7110	6988	6869	6753	6640	6530	6423
2	7777	7634	7497	7363	7234	7108	6986	6867	6751	6638	6528	6421
3	7774	7632	7494	7361	7232	7106	6984	6865	6749	6637	6527	6420
4	7772	7630	7492	7359	7229	7104	6982	6863	6747	6635	6525	6418
5	7769	7627	7490	7357	7227	7102	6980	6861	6745	6633	6523	6416
6	7767	7625	7488	7354	7225	7100	6978	6859	6743	6631	6521	6414
7	7765	7623	7485	7352	7223	7098	6976	6857	6742	6629	6519	6412
8	7762	7620	7483	7350	7221	7095	6974	6855	6740	6627	6518	6411
9	7760	7618	7481	7348	7219	7093	6972	6853	6738	6625	6516	6409
10	7757	7616	7479	7346	7217	7091	6970	6851	6736	6624	6514	6407
11	7755	7613	7476	7343	7215	7089	6968	6849	6734	6622	6512	6405
12	7753	7611	7474	7341	7212	7087	6966	6847	6732	6620	6510	6404
13	7750	7609	7472	7339	7210	7085	6964	6845	6730	6618	6509	6402
14	7748	7606	7470	7337	7208	7083	6962	6843	6728	6616	6507	6400
15	7745	7604	7467	7335	7206	7081	6960	6841	6726	6614	6505	6398
16	7743	7602	7465	7333	7204	7079	6958	6839	6724	6612	6503	6397
17	7741	7600	7463	7330	7202	7077	6956	6838	6723	6614	6501	6395
18	7738	7597	7461	7328	7200	7075	6954	6836	6721	6609	6500	6393
19	7736	7595	7458	7326	7198	7073	6952	6834	6719	6607	6498	6391
20	7734	7593	7456	7324	7196	7071	6950	6832	6717	6605	6496	6390
21	7731	7590	7454	7322	7193	7069	6948	6830	6715	6603	6494	6388
22	7729	7588	7452	7320	7191	7067	6946	6828	6713	6601	6492	6386
23	7726	7586	7449	7317	7189	7065	6944	6826	6711	6600	6491	6384
24	7724	7583	7447	7315	7187	7063	6942	6824	6709	6598	6489	6383
25	7722	7581	7445	7313	7185	7061	6940	6822	6707	6596	6487	6381
26	7719	7579	7443	7311	7183	7059	6938	6820	6706	6594	6485	6379
27	7717	7577	7441	7309	7181	7057	6936	6818	6704	6592	6484	6377
28	7714	7574	7438	7307	7179	7054	6934	6816	6702	6590	6482	6376
29	7712	7572	7436	7304	7177	7052	6932	6814	6700	6589	6480	6374
30	7710	7570	7434	7302	7175	7050	6930	6812	6698	6587	6478	6372
31	7707	7567	7432	7300	7172	7048	6928	6810	6696	6585	6476	6370
32	7705	7565	7429	7298	7170	7046	6926	6809	6694	6583	6475	6369
33	7703	7563	7427	7296	7168	7044	6924	6807	6692	6581	6473	6367
34	7700	7560	7425	7294	7166	7042	6922	6805	6691	6579	6471	6365
35	7698	7558	7423	7291	7164	7040	6920	6803	6689	6578	6469	6363
36	7696	7556	7421	7289	7162	7038	6918	6801	6687	6576	6467	6362
37	7693	7554	7418	7287	7160	7036	6916	6799	6685	6574	6466	6360
38	7691	7551	7416	7285	7158	7034	6914	6797	6683	6572	6464	6358
39	7688	7549	7414	7283	7156	7032	6912	6795	6681	6570	6462	6357
40	7686	7547	7412	7281	7154	7030	6910	6793	6679	6568	6460	6355
41	7684	7544	7409	7279	7152	7028	6908	6791	6677	6567	6459	6353
42	7681	7542	7407	7276	7149	7026	6906	6789	6676	6565	6457	6351
43	7679	7540	7405	7274	7147	7024	6904	6787	6674	6563	6455	6350
44	7677	7538	7403	7272	7145	7022	6902	6785	6672	6561	6453	6348
45	7674	7535	7401	7270	7143	7020	6900	6784	6670	6559	6451	6346
46	7672	7533	7398	7268	7141	7018	6898	6782	6668	6557	6450	6344
47	7670	7531	7396	7266	7139	7016	6896	6780	6666	6556	6448	6343
48	7667	7528	7394	7264	7137	7014	6894	6778	6664	6554	6446	6341
49	7665	7526	7392	7261	7135	7012	6892	6776	6662	6552	6444	6339
50	7662	7524	7390	7259	7133	7010	6890	6774	6661	6550	6443	6338
51	7660	7522	7387	7257	7131	7008	6888	6772	6659	6548	6441	6336
52	7658	7519	7385	7255	7129	7006	6886	6770	6657	6547	6439	6334
53	7655	7517	7383	7253	7126	7004	6884	6768	6655	6545	6437	6332
54	7653	7515	7381	7251	7124	7002	6882	6766	6653	6543	6435	6331
55	7651	7513	7379	7249	7122	7000	6880	6764	6651	6541	6434	6329
56	7648	7510	7376	7246	7120	6998	6878	6762	6649	6539	6432	6327
57	7646	7508	7374	7244	7118	6996	6877	6761	6648	6538	6430	6325
58	7644	7506	7372	7242	7116	6994	6875	6759	6646	6536	6428	6324
59	7641	7503	7370	7240	7114	6992	6873	6757	6644	6534	6427	6322

TABLE XXIX.

Proportional Logarithms.

s.	h. m. 0°42′	h. m. 0°43′	h. m. 0°44′	h. m. 0°45′	h. m. 0°46′	h. m. 0°47′	h. m. 0°48′	h. m. 0°49′	h. m. 0°50′	h. m. 0°51′	h. m. 0°52′	h. m. 0°53′
0	6320	6218	6118	6021	5925	5832	5740	5651	5563	5477	5393	5310
1	6318	6216	6117	6019	5924	5830	5739	5649	5562	5476	5391	5309
2	6317	6215	6115	6017	5922	5829	5737	5648	5560	5474	5390	5307
3	6315	6213	6113	6016	5920	5827	5736	5646	5559	5473	5389	5306
4	6313	6211	6111	6014	5919	5826	5734	5645	5557	5471	5387	5304
5	6312	6210	6110	6013	5917	5824	5733	5643	5556	5470	5386	5303
6	6310	6208	6108	6011	5916	5823	5731	5642	5554	5469	5384	5302
7	6308	6206	6107	6009	5914	5821	5730	5640	5553	5467	5383	5300
8	6306	6205	6105	6008	5913	5819	5728	5639	5551	5466	5382	5299
9	6305	6203	6103	6006	5911	5818	5727	5637	5550	5464	5380	5298
10	6303	6201	6102	6004	5909	5816	5725	5636	5549	5463	5379	5296
11	6301	6200	6100	6003	5908	5815	5724	5634	5547	5461	5377	5295
12	6300	6198	6099	6001	5906	5813	5722	5633	6546	5460	5376	5294
13	6298	6196	6097	6000	5905	5812	5721	5632	5544	5459	5375	5292
14	6296	6194	6095	5998	5903	5810	5719	5630	5543	5457	5373	5291
15	6294	6193	6094	5997	5902	5809	5718	5629	5541	5456	5372	5290
16	6293	6191	6092	5995	5900	5807	5716	5627	5540	5454	5370	5288
17	6291	6189	6090	5993	5898	5806	5715	5626	5538	5453	5369	5287
18	6289	6188	6089	5992	5897	5804	5713	5624	5537	5452	5368	5285
19	6288	6186	6087	5990	5895	5803	5712	5623	5536	5450	5366	5284
20	6286	6184	6085	5988	5894	5801	5710	5621	5534	5449	5365	5283
21	6284	6183	6084	5987	5892	5800	5709	5620	5533	5447	5364	5281
22	6282	6181	6082	5985	5891	5798	5707	5618	5531	5446	5362	5280
23	6281	6179	6080	5984	5889	5796	5706	5617	5530	5444	5361	5279
24	6279	6178	6079	5982	5888	5795	5704	5615	5528	5443	5359	5277
25	6277	6176	6077	5981	5886	5793	5703	5614	5527	5442	5358	5276
26	6276	6174	6076	5979	5884	5792	5701	5612	5525	5440	5357	5275
27	6274	6173	6074	5977	5883	5790	5700	5611	5524	5439	5355	5273
28	6272	6171	6072	5976	5881	5789	5698	5610	5523	5437	5354	5272
29	6270	6169	6071	5974	5880	5787	5697	5608	5521	5436	5352	5270
30	6269	6168	6069	5973	5878	5786	5695	5607	5520	5435	5351	5269
31	6267	6166	6067	5971	5877	5784	5694	5605	5518	5433	5350	5268
32	6265	6164	6066	5969	5875	5783	5692	5604	5517	5432	5348	5266
33	6264	6163	6064	5968	5874	5781	5691	5602	5516	5430	5347	5265
34	6262	6161	6063	5966	5872	5780	5689	5601	5514	5429	5346	5264
35	6260	6159	6061	5965	5870	5778	5688	5599	5513	5428	5344	5262
36	6259	6158	6059	5963	5869	5777	5686	5598	5511	5426	5343	5261
37	6257	6156	6058	5961	5867	5775	5685	5596	5510	5425	5341	5260
38	6255	6154	6056	5960	5866	5774	5683	5595	5508	5423	5340	5258
39	6254	6153	6055	5958	5864	5772	5682	5594	5507	5422	5339	5257
40	6252	6151	6053	5957	5863	5771	5680	5592	5505	5421	5337	5256
41	6250	6150	6051	5955	5861	5769	5679	5591	5504	5419	5336	5254
42	6248	6148	6050	5954	5860	5768	5677	5589	5503	5418	5335	5253
43	6247	6146	6048	5952	5858	5766	5676	5588	5501	5416	5333	5252
44	6245	6145	6046	5950	5856	5764	5674	5586	5500	5415	5332	5250
45	6243	6143	6045	5949	5855	5763	5673	5585	5498	5414	5331	5249
46	6242	6141	6043	5947	5853	5761	5671	5583	5497	5412	5329	5248
47	6240	6140	6042	5946	5852	5760	5670	5582	5495	5411	5328	5246
48	6238	6138	6040	5944	5850	5758	5669	5580	5494	5409	5326	5245
49	6237	6136	6038	5942	5849	5757	5667	5579	5493	5408	5325	5244
50	6235	6135	6037	5941	5847	5755	5666	5577	5491	5407	5324	5242
51	6233	6133	6035	5939	5846	5754	5664	5576	5490	5405	5322	5241
52	6231	6131	6033	5938	5844	5752	5663	5575	5488	5404	5321	5239
53	6230	6130	6032	5936	5842	5751	5661	5573	5487	5402	5319	5238
54	6228	6128	6030	5935	5841	5749	5660	5572	5486	5401	5318	5237
55	6226	6126	6029	5933	5839	5748	5658	5570	5484	5400	5317	5235
56	6225	6125	6027	5931	5838	5746	5657	5569	5483	5398	5315	5234
57	6223	6123	6025	5930	5836	5745	5655	5567	5481	5397	5314	5233
58	6221	6121	6024	5928	5835	5743	5654	5566	5480	5395	5313	5231
59	6220	6120	6022	5927	5833	5742	5652	5564	5478	5394	5311	5230

Proportional Logarithms.

s.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
″	0°54′	0°55′	0°56′	0°57′	0°58′	0°59′	1° 0′	1° 1′	1° 2′	1° 3′	1° 4′	1° 5′
0	5229	5149	5071	4994	4918	4844	4771	4699	4629	4559	4491	4424
1	5227	5148	5070	4993	4917	4843	4770	4698	4627	4558	4490	4422
2	5226	5146	5068	4991	4916	4842	4769	4697	4626	4557	4489	4421
3	5225	5145	5067	4990	4915	4841	4768	4696	4625	4556	4488	4420
4	5223	5144	5066	4989	4913	4839	4766	4694	4624	4555	4486	4419
5	5222	5142	5064	4988	4912	4838	4765	4693	4623	4554	4485	4418
6	5221	5141	5063	4986	4911	4837	4764	4692	4622	4552	4484	4417
7	5219	5140	5062	4985	4910	4836	4763	4691	4620	4551	4483	4416
8	5218	5139	5060	4984	4908	4834	4762	4690	4619	4550	4482	4415
9	5217	5137	5059	4983	4907	4833	4760	4689	4618	4549	4481	4414
10	5215	5136	5058	4981	4906	4832	4759	4688	4617	4548	4480	4412
11	5214	5135	5057	4980	4905	4831	4758	4686	4616	4547	4478	4411
12	5213	5133	5055	4979	4903	4830	4757	4685	4615	4546	4477	4410
13	5211	5132	5054	4977	4902	4828	4756	4684	4614	4544	4476	4409
14	5210	5131	5053	4976	4901	4827	4754	4683	4612	4543	4475	4408
15	5209	5129	5051	4975	4900	4826	4753	4682	4611	4542	4474	4407
16	5207	5128	5050	4974	4898	4824	4752	4680	4610	4541	4473	4406
17	5206	5127	5049	4972	4897	4823	4751	4679	4609	4540	4472	4405
18	5205	5125	5048	4971	4896	4822	4750	4678	4608	4539	4471	4404
19	5203	5124	5046	4970	4895	4821	4748	4677	4607	4537	4469	4402
20	5202	5123	5045	4969	4894	4820	4747	4676	4605	4536	4468	4401
21	5201	5122	5044	4967	4892	4819	4746	4675	4604	4535	4467	4400
22	5199	5120	5042	4966	4891	4817	4745	4673	4603	4534	4466	4399
23	5198	5119	5041	4965	4890	4816	4744	4672	4602	4533	4465	4398
24	5197	5118	5040	4964	4889	4815	4742	4671	4601	4532	4464	4397
25	5195	5116	5039	4962	4887	4814	4741	4670	4600	4531	4463	4396
26	5194	5115	5037	4961	4886	4812	4740	4669	4599	4529	4462	4395
27	5193	5114	5036	4960	4885	4811	4739	4668	4597	4528	4460	4394
28	5191	5112	5035	4959	4884	4810	4737	4666	4596	4527	4459	4392
29	5190	5111	5033	4957	4882	4809	4736	4665	4595	4526	4458	4391
30	5189	5110	5032	4956	4881	4808	4735	4664	4594	4525	4457	4390
31	5187	5108	5031	4955	4880	4806	4734	4663	4593	4524	4456	4389
32	5186	5107	5030	4953	4879	4805	4733	4662	4592	4523	4455	4388
33	5185	5106	5028	4952	4877	4804	4732	4660	4590	4522	4454	4387
34	5183	5105	5027	4951	4876	4803	4730	4659	4589	4520	4453	4386
35	5182	5103	5026	4950	4875	4801	4729	4658	4588	4519	4451	4385
36	5181	5102	5025	4949	4874	4800	4728	4657	4587	4518	4450	4384
37	5179	5101	5023	4947	4872	4799	4727	4656	4586	4517	4449	4382
38	5178	5099	5022	4946	4871	4798	4726	4655	4585	4516	4448	4381
39	5177	5098	5021	4945	4870	4797	4724	4653	4584	4515	4447	4380
40	5175	5097	5019	4943	4869	4795	4723	4652	4582	4514	4446	4379
41	5174	5095	5018	4942	4868	4794	4722	4651	4581	4512	4445	4378
42	5173	5094	5017	4941	4866	4793	4721	4650	4580	4511	4444	4377
43	5171	5093	5016	4940	4865	4792	4720	4649	4579	4510	4443	4376
44	5170	5092	5014	4938	4864	4791	4718	4647	4578	4509	4441	4375
45	5169	5090	5013	4937	4863	4789	4717	4646	4577	4508	4440	4374
46	5167	5089	5012	4936	4861	4788	4716	4645	4575	4507	4439	4373
47	5166	5088	5010	4935	4860	4787	4715	4644	4574	4506	4438	4372
48	5165	5086	5009	4933	4859	4786	4714	4643	4573	4505	4437	4370
49	5163	5085	5008	4932	4858	4784	4712	4642	4572	4503	4436	4369
50	5162	5084	5007	4931	4856	4783	4711	4640	4571	4502	4435	4368
51	5161	5082	5005	4930	4855	4782	4710	4639	4570	4501	4434	4367
52	5159	5081	5004	4928	4854	4781	4709	4638	4568	4500	4432	4366
53	5158	5080	5003	4927	4853	4780	4708	4637	4567	4499	4431	4365
54	5157	5079	5002	4926	4852	4778	4707	4636	4566	4498	4430	4364
55	5156	5077	5000	4925	4850	4777	4705	4635	4565	4497	4429	4363
56	5154	5076	4999	4923	4849	4776	4704	4633	4564	4495	4428	4362
57	5153	5075	4998	4922	4848	4775	4703	4632	4563	4494	4427	4361
58	5152	5073	4996	4921	4846	4774	4702	4631	4562	4493	4426	4359
59	5150	5072	4995	4920	4845	4772	4701	4630	4560	4492	4425	4358

TABLE XXIX.

Proportional Logarithms.

s. / "	h. m. 1° 6′	h. m. 1° 7′	h. m. 1° 8′	h. m. 1° 9′	h. m. 1°10′	h. m. 1°11′	h. m. 1°12′	h. m. 1°13′	h. m. 1°14′	h. m. 1°15′	h. m. 1°16′	h. m. 1°17′
0	4357	4292	4228	4164	4102	4040	3979	3919	3860	3802	3745	3688
1	4356	4291	4227	4163	4101	4039	3978	3918	3859	3801	3744	3687
2	4355	4290	4225	4162	4100	4038	3977	3917	3858	3800	3743	3686
3	4354	4289	4224	4161	4099	4037	3976	3917	3857	3799	3742	3685
4	4353	4288	4223	4160	4098	4036	3975	3916	3856	3798	3741	3684
5	4352	4287	4222	4159	4097	4035	3974	3915	3855	3797	3740	3683
6	4351	4285	4221	4158	4096	4034	3973	3914	3855	3796	3739	3682
7	4350	4284	4220	4157	4094	4033	3972	3913	3854	3795	3738	3681
8	4348	4283	4219	4156	4093	4032	3971	3912	3853	3794	3737	3680
9	4347	4282	4218	4155	4092	4031	3970	3911	3852	3793	3736	3679
10	4346	4281	4217	4154	4091	4030	3969	3910	3851	3792	3735	3678
11	4345	4280	4216	4153	4090	4029	3968	3909	3850	3791	3734	3677
12	4344	4279	4215	4152	4089	4028	3967	3908	3849	3791	3733	3677
13	4343	4278	4214	4151	4088	4027	3966	3907	3848	3790	3732	3676
14	4342	4277	4213	4150	4087	4026	3965	3906	3847	3789	3731	3675
15	4341	4276	4212	4149	4086	4025	3964	3905	3846	3788	3730	3674
16	4340	4275	4211	4147	4085	4024	3963	3904	3845	3787	3729	3673
17	4339	4274	4210	4146	4084	4023	3962	3903	3844	3786	3728	3672
18	4338	4273	4209	4145	4083	4022	3961	3902	3843	3785	3727	3671
19	4336	4271	4207	4144	4082	4021	3960	3901	3842	3784	3726	3670
20	4335	4270	4206	4143	4081	4020	3959	3900	3841	3783	3726	3669
21	4334	4269	4205	4142	4080	4019	3958	3899	3840	3782	3725	3668
22	4333	4268	4204	4141	4079	4018	3957	3898	3839	3781	3724	3667
23	4332	4267	4203	4140	4078	4017	3956	3897	3838	3780	3723	3666
24	4331	4266	4202	4139	4077	4016	3955	3896	3837	3779	3722	3665
25	4330	4265	4201	4138	4076	4015	3954	3895	3836	3778	3721	3664
26	4329	4264	4200	4137	4075	4014	3953	3894	3835	3777	3720	3663
27	4328	4263	4199	4136	4074	4013	3952	3893	3834	3776	3719	3663
28	4327	4262	4198	4135	4073	4012	3951	3892	3833	3775	3718	3662
29	4326	4261	4197	4134	4072	4011	3950	3891	3832	3774	3717	3661
30	4325	4260	4196	4133	4071	4010	3949	3890	3831	3773	3716	3660
31	4323	4259	4195	4132	4070	4009	3948	3889	3830	3772	3715	3659
32	4322	4257	4194	4131	4069	4008	3947	3888	3829	3771	3714	3658
33	4321	4256	4193	4130	4068	4007	3946	3887	3828	3770	3713	3657
34	4320	4255	4192	4129	4067	4006	3945	3886	3827	3769	3712	3656
35	4319	4254	4190	4128	4066	4005	3944	3885	3826	3768	3711	3655
36	4318	4253	4189	4127	4065	4004	3943	3884	3825	3768	3710	3654
37	4317	4252	4188	4126	4064	4003	3942	3883	3824	3767	3709	3653
38	4316	4251	4187	4125	4063	4002	3941	3882	3823	3766	3708	3652
39	4315	4250	4186	4124	4062	4001	3940	3881	3822	3765	3708	3651
40	4314	4249	4185	4122	4061	4000	3939	3880	3821	3764	3707	3650
41	4313	4248	4184	4121	4060	3999	3938	3879	3820	3763	3706	3649
42	4311	4247	4183	4120	4059	3998	3937	3878	3820	3762	3705	3649
43	4310	4246	4182	4119	4057	3997	3936	3877	3819	3761	3704	3648
44	4309	4245	4181	4118	4056	3996	3935	3876	3818	3760	3703	3647
45	4308	4244	4180	4117	4055	3995	3934	3875	3817	3759	3702	3646
46	4307	4243	4179	4116	4054	3993	3933	3874	3816	3758	3701	3645
47	4306	4241	4178	4115	4053	3992	3932	3873	3815	3757	3700	3644
48	4305	4240	4177	4114	4052	3991	3931	3872	3814	3756	3699	3643
49	4304	4239	4176	4113	4051	3990	3930	3871	3813	3755	3698	3642
50	4303	4238	4175	4112	4050	3989	3929	3870	3812	3754	3697	3641
51	4302	4237	4174	4111	4049	3988	3928	3869	3811	3753	3696	3640
52	4301	4236	4173	4110	4048	3987	3927	3868	3810	3752	3695	3639
53	4299	4235	4172	4109	4047	3986	3926	3867	3809	3751	3694	3638
54	4298	4234	4171	4108	4046	3985	3925	3866	3808	3750	3693	3637
55	4297	4233	4169	4107	4045	3984	3924	3865	3807	3749	3692	3636
56	4296	4232	4168	4106	4044	3983	3923	3864	3806	3748	3691	3635
57	4295	4231	4167	4105	4043	3982	3922	3863	3805	3747	3692	3635
58	4294	4230	4166	4104	4042	3981	3921	3862	3804	3746	3690	3634
59	4293	4229	4165	4103	4041	3980	3920	3861	3803	3745	3689	3633

Proportional Logarithms.

s.	h. m. 1°18′	h. m. 1°19′	h. m. 1°20′	h. m. 1°21′	h. m. 1°22′	h. m. 1°23′	h. m. 1°24′	h. m. 1°25′	h. m. 1°26′	h. m. 1°27′	h. m. 1°28′	h. m. 1°29′
0	3632	3576	3522	3468	3415	3362	3310	3259	3208	3158	3108	3059
1	3631	3575	3521	3467	3414	3361	3309	3258	3207	3157	3107	3058
2	3630	3575	3520	3466	3413	3360	3308	3257	3206	3156	3106	3057
3	3629	3574	3519	3465	3412	3359	3307	3256	3205	3155	3105	3056
4	3628	3573	3518	3464	3411	3358	3306	3255	3204	3154	3105	3056
5	3627	3572	3517	3463	3410	3358	3306	3254	3203	3153	3104	3055
6	3626	3571	3516	3463	3409	3357	3305	3253	3203	3153	3103	3054
7	3625	3570	3515	3462	3408	3356	3304	2253	3202	3152	3102	3053
8	3624	3569	3515	3461	3407	3355	3303	3252	3201	3151	3101	3052
9	3623	3568	3514	3460	3407	3354	3302	3251	3200	3150	3101	3052
10	3622	3567	3513	3459	3406	3353	3301	3250	3199	3149	3100	3051
11	3622	3566	3512	3458	3405	3352	3300	3249	3198	3148	3099	3050
12	3621	3565	3511	3457	3404	3351	3300	3248	3198	3148	3098	3049
13	3620	3565	3510	3456	3403	3351	3299	3247	3197	3147	3097	3048
14	3619	3564	3509	3455	3402	3350	3298	3247	3196	3146	3097	3047
15	3618	3563	3508	3454	3401	3349	3297	3246	3195	3145	3096	3047
16	3617	3562	3507	3454	3400	3348	3296	3245	3194	3144	3095	3046
17	3616	3561	3506	3453	3400	3347	3295	3244	3193	3143	3094	3045
18	3615	3560	3506	3452	3399	3346	3294	3243	3193	3143	3093	3044
19	3614	3559	3505	3451	3398	3345	3294	3242	3192	3142	3092	3043
20	3613	3558	3504	3450	3397	3344	3293	3241	3191	3141	3091	3043
21	3612	3557	3503	3449	3396	3344	3292	3241	3190	3140	3091	3042
22	3611	3556	3502	3448	3395	3343	3291	3240	3189	3139	3090	3041
23	3610	3555	3501	3447	3394	3342	3290	3239	3188	3138	3089	3040
24	3610	3555	3500	3446	3393	3341	3289	3238	3188	3138	3088	3039
25	3609	3554	3499	3446	3393	3340	3288	3237	3187	3137	3087	3038
26	3608	3553	3498	3445	3392	3339	3287	3236	3186	3136	3087	3038
27	3607	3552	3497	3444	3391	3338	3287	3236	3185	3135	3086	3037
28	3606	3551	3496	3443	3390	3338	3286	3235	3184	3134	3085	3036
29	3605	3550	3496	3442	3389	3337	3285	3234	3183	3133	3084	3035
30	3604	3549	3495	3441	3388	3336	3284	3233	3183	3133	3083	3034
31	3603	3548	3494	3440	3387	3335	3283	3232	3182	3132	3082	3034
32	3602	3547	3493	3439	3386	3334	3282	3231	3181	3131	3082	3033
33	3601	3546	3492	3438	3386	3333	3282	3231	3180	3130	3081	3032
34	3600	3545	3491	3438	3385	3332	3281	3230	3179	3129	3080	3031
35	3599	3544	3490	3437	3384	3331	3280	3229	3178	3128	3079	3030
36	3598	3544	3489	3436	3383	3331	3279	3228	3178	3128	3078	3030
37	3598	3543	3488	3435	3382	3330	3278	3227	3177	3127	3078	3029
38	3597	3542	3488	3434	3381	3329	3277	3226	3176	3126	3077	3028
39	3596	3541	3487	3433	3380	3328	3276	3225	3175	3125	3076	3027
40	3595	3540	3486	3432	3379	3327	3276	3225	3174	3124	3075	3026
41	3594	3539	3485	3431	3378	3326	3275	3224	3173	3124	3074	3026
42	3593	3538	3484	3431	3378	3325	3274	3223	3173	3123	3073	3025
43	3592	3537	3483	3430	3377	3325	3273	3222	3172	3122	3073	3024
44	3591	3536	3482	3429	3376	3324	3272	3221	3171	3121	3072	3023
45	3590	3535	3481	3428	3375	3323	3271	3220	3170	3120	3071	3022
46	3589	3534	3480	3427	3374	3322	3270	3219	3169	3119	3070	3022
47	3588	3533	3479	3426	3373	3321	3270	3219	3168	3119	3069	3021
48	3587	3533	3479	3425	3372	3320	3269	3218	3168	3118	3069	3020
49	3586	3532	3478	3424	3371	3319	3268	3217	3167	3117	3068	3019
50	3586	3531	3477	3423	3371	3319	3267	3216	3166	3116	3067	3018
51	3585	3530	3476	3423	3370	3318	3266	3215	3165	3115	3066	3018
52	3584	3529	3475	3422	3369	3317	3265	3214	3164	3114	3065	3017
53	3583	3528	3474	3421	3368	3316	3264	3214	3163	3114	3064	3016
54	3582	3527	3473	3420	3367	3315	3264	3213	3163	3113	3064	3015
55	3581	3526	3472	3419	3366	3314	3263	3212	3162	3112	3063	3014
56	3580	3525	3471	3418	3365	3313	3262	3211	3161	3111	3062	3013
57	3579	3525	3471	3417	3365	3313	3261	3210	3160	3110	3061	3013
58	3578	3524	3470	3416	3364	3312	3260	3209	3159	3109	3060	3012
59	3577	3523	3469	3415	3363	3311	3259	3209	3158	3109	3060	3011

TABLE XXIX.

Proportional Logarithms.

s. / ″	h. m. 1°30′	h. m. 1°31′	h. m. 1°32′	h. m. 1°33′	h. m. 1°34′	h. m. 1°35′	h. m. 1°36′	h. m. 1°37′	h. m. 1°38′	h. m. 1°39′	h. m. 1°40′	h. m. 1°41′
0	3010	2962	2915	2868	2821	2775	2730	2685	2640	2596	2553	2510
1	3009	2961	2914	2867	2821	2775	2729	2684	2640	2596	2552	2509
2	3009	2961	2913	2866	2820	2774	2728	2683	2639	2595	2551	2508
3	3008	2960	2912	2866	2819	2773	2728	2683	2638	2594	2551	2507
4	3007	2959	2912	2865	2818	2772	2727	2682	2637	2593	2550	2507
5	3006	2958	2911	2864	2818	2772	2726	2681	2637	2593	2549	2506
6	3005	2958	2910	2863	2817	2771	2725	2681	2636	2592	2548	2505
7	3005	2957	2909	2862	2816	2770	2725	2680	2635	2591	2548	2504
8	3004	2956	2909	2862	2815	2769	2724	2679	2634	2590	2547	2504
9	3003	2955	2908	2861	2815	2769	2723	2678	2634	2590	2546	2503
10	3002	2954	2907	2860	2814	2768	2722	2678	2633	2589	2545	2502
11	3001	2954	2906	2859	2813	2767	2722	2677	2632	2588	2545	2502
12	3001	2953	2905	2859	2812	2766	2721	2676	2632	2588	2544	2501
13	3000	2952	2905	2858	2811	2766	2720	2675	2631	2587	2543	2500
14	2999	2951	2904	2857	2811	2765	2719	2675	2630	2586	2543	2499
15	2998	2950	2903	2856	2810	2764	2719	2674	2629	2585	2542	2499
16	2997	2950	2902	2855	2809	2763	2718	2673	2629	2585	2541	2498
17	2997	2949	2901	2855	2808	2763	2717	2672	2628	2584	2540	2497
18	2996	2948	2901	2854	2808	2762	2716	2672	2627	2583	2540	2497
19	2995	2947	2900	2853	2807	2761	2716	2671	2626	2582	2539	2496
20	2994	2946	2899	2852	2806	2760	2715	2670	2626	2582	2538	2495
21	2993	2946	2898	2852	2805	2760	2714	2669	2625	2581	2538	2494
22	2993	2945	2898	2851	2804	2759	2713	2669	2624	2580	2537	2494
23	2992	2944	2897	2850	2804	2758	2713	2668	2623	2580	2536	2493
24	2991	2943	2896	2849	2803	2757	2712	2667	2623	2579	2535	2492
25	2990	2942	2895	2848	2802	2756	2711	2666	2622	2578	2535	2492
26	2989	2942	2894	2848	2801	2756	2710	2666	2621	2577	2534	2491
27	2989	2941	2894	2847	2801	2755	2710	2665	2621	2577	2533	2490
28	2988	2940	2893	2846	2800	2754	2709	2664	2620	2576	2532	2489
29	2987	2939	2892	2845	2799	2753	2708	2663	2619	2575	2532	2489
30	2986	2939	2891	2845	2798	2753	2707	2663	2618	2574	2531	2488
31	2985	2938	2890	2844	2798	2752	2707	2662	2618	2574	2530	2487
32	2985	2937	2890	2843	2797	2751	2706	2661	2617	2573	2530	2487
33	2984	2936	2889	2842	2796	2750	2705	2660	2616	2572	2529	2486
34	2983	2935	2888	2841	2795	2750	2704	2660	2615	2572	2528	2485
35	2982	2935	2887	2841	2795	2749	2704	2659	2615	2571	2527	2484
36	2981	2934	2887	2840	2794	2748	2703	2658	2614	2570	2527	2484
37	2981	2933	2886	2839	2793	2747	2702	2657	2613	2569	2526	2483
38	2980	2932	2885	2838	2792	2747	2701	2657	2612	2569	2525	2482
39	2979	2931	2884	2838	2792	2746	2701	2656	2612	2568	2525	2482
40	2978	2931	2883	2837	2791	2745	2700	2655	2611	2567	2524	2481
41	2977	2930	2883	2836	2790	2744	2699	2654	2610	2566	2523	2480
42	2977	2929	2882	2835	2789	2744	2698	2654	2610	2566	2522	2480
43	2976	2928	2881	2835	2788	2743	2698	2653	2609	2565	2522	2479
44	2975	2927	2880	2834	2788	2742	2697	2652	2608	2564	2521	2478
45	2974	2927	2880	2833	2787	2741	2696	2652	2607	2564	2520	2477
46	2973	2926	2879	2832	2786	2741	2695	2651	2607	2563	2520	2477
47	2973	2925	2878	2831	2785	2740	2695	2650	2606	2562	2519	2476
48	2972	2924	2877	2831	2785	2739	2694	2649	2605	2561	2518	2475
49	2971	2923	2876	2830	2784	2738	2693	2649	2604	2561	2517	2474
50	2970	2923	2876	2829	2783	2738	2692	2648	2604	2560	2517	2474
51	2969	2922	2875	2828	2782	2737	2692	2647	2603	2559	2516	2473
52	2969	2921	2874	2828	2782	2736	2691	2646	2602	2558	2515	2472
53	2968	2920	2873	2827	2781	2735	2690	2646	2601	2558	2514	2472
54	2967	2920	2873	2826	2780	2735	2689	2645	2601	2557	2514	2471
55	2966	2919	2872	2825	2779	2734	2689	2644	2600	2556	2513	2470
56	2965	2918	2871	2824	2778	2733	2688	2643	2599	2556	2512	2470
57	2965	2917	2870	2824	2778	2732	2687	2643	2599	2555	2512	2469
58	2964	2916	2869	2823	2777	2731	2686	2642	2598	2554	2511	2468
59	2963	2916	2869	2822	2776	2731	2686	2641	2597	2553	2510	2467

Proportional Logarithms.

s.	h. m. 1°42′	h. m. 1°43′	h. m. 1°44′	h. m. 1°45′	h. m. 1°46′	h. m. 1°47′	h. m. 1°48′	h. m. 1°49′	h. m. 1°50′	h. m. 1°51′	h. m. 1°52′	h. m. 1°53′
0	2467	2424	2382	2341	2300	2259	2218	2178	2139	2099	2061	2022
1	2466	2424	2382	2340	2299	2258	2218	2178	2138	2099	2060	2021
2	2465	2423	2381	2339	2298	2257	2217	2177	2137	2098	2059	2021
3	2465	2422	2380	2339	2298	2257	2216	2176	2137	2098	2059	2020
4	2464	2421	2380	2338	2297	2256	2216	2176	2136	2097	2058	2019
5	2463	2421	2379	2337	2296	2255	2215	2175	2135	2096	2057	2019
6	2462	2420	2378	2337	2296	2255	2214	2174	2135	2096	2057	2018
7	2462	2419	2378	2336	2295	2254	2214	2174	2134	2095	2056	2017
8	2461	2419	2377	2335	2294	2253	2213	2173	2133	2094	2055	2017
9	2460	2418	2376	2335	2294	2253	2212	2172	2133	2094	2055	2016
10	2460	2417	2375	2334	2293	2252	2212	2172	2132	2093	2054	2016
11	2459	2417	2375	2333	2292	2251	2211	2171	2132	2092	2053	2015
12	2458	2416	2374	2333	2291	2251	2210	2170	2131	2092	2053	2014
13	2457	2415	2373	2332	2291	2250	2210	2170	2130	2091	2052	2014
14	2457	2414	2373	2331	2290	2249	2209	2169	2130	2090	2051	2013
15	2456	2414	2372	2331	2289	2249	2208	2169	2129	2090	2051	2012
16	2455	2413	2371	2330	2289	2248	2208	2168	2128	2089	2050	2012
17	2455	2412	2371	2329	2288	2247	2207	2167	2128	2088	2050	2011
18	2454	2412	2370	2328	2287	2247	2206	2167	2127	2088	2049	2010
19	2453	2411	2369	2328	2287	2246	2206	2166	2126	2087	2048	2010
20	2453	2410	2368	2327	2286	2245	2205	2165	2126	2086	2048	2009
21	2452	2410	2368	2326	2285	2245	2204	2165	2125	2086	2047	2009
22	2451	2409	2367	2326	2285	2244	2204	2164	2124	2085	2046	2008
23	2450	2408	2366	2325	2284	2243	2203	2163	2124	2084	2046	2007
24	2450	2408	2366	2324	2283	2243	2202	2163	2123	2084	2045	2007
25	2449	2407	2365	2324	2283	2242	2202	2162	2122	2083	2044	2006
26	2448	2406	2364	2323	2282	2241	2201	2161	2122	2083	2044	2005
27	2448	2405	2364	2322	2281	2241	2200	2161	2121	2082	2043	2005
28	2447	2405	2363	2322	2281	2240	2200	2160	2120	2081	2042	2004
29	2446	2404	2362	2321	2280	2239	2199	2159	2120	2081	2042	2003
30	2445	2403	2362	2320	2279	2239	2198	2159	2119	2080	2041	2003
31	2445	2403	2361	2319	2279	2238	2198	2158	2118	2079	2041	2002
32	2444	2402	2360	2319	2278	2237	2197	2157	2118	2079	2040	2001
33	2443	2401	2359	2318	2277	2237	2196	2157	2117	2078	2039	2001
34	2443	2400	2359	2317	2276	2236	2196	2156	2116	2077	2039	2000
35	2442	2400	2358	2317	2276	2235	2195	2155	2116	2077	2038	2000
36	2441	2399	2357	2316	2275	2235	2194	2155	2115	2076	2037	1999
37	2440	2398	2357	2315	2274	2234	2194	2154	2114	2075	2037	1998
38	2440	2398	2356	2315	2274	2233	2193	2153	2114	2075	2036	1998
39	2439	2397	2355	2314	2273	2233	2192	2153	2113	2074	2035	1997
40	2438	2396	2355	2313	2272	2232	2192	2152	2113	2073	2035	1996
41	2438	2396	2354	2313	2272	2231	2191	2151	2112	2073	2034	1996
42	2437	2395	2353	2312	2271	2231	2190	2151	2111	2072	2033	1995
43	2436	2394	2353	2311	2270	2230	2190	2150	2111	2071	2033	1994
44	2436	2394	2352	2311	2270	2229	2189	2149	2110	2071	2032	1994
45	2435	2393	2351	2310	2269	2229	2188	2149	2109	2070	2032	1993
46	2434	2392	2350	2309	2268	2228	2188	2148	2109	2070	2031	1993
47	2433	2391	2350	2308	2268	2227	2187	2147	2108	2069	2030	1992
48	2433	2391	2349	2308	2267	2227	2186	2147	2107	2068	2030	1991
49	2432	2390	2348	2307	2266	2226	2186	2146	2107	2068	2029	1991
50	2431	2389	2348	2306	2266	2225	2185	2145	2106	2067	2028	1990
51	2431	2389	2347	2306	2265	2225	2184	2145	2105	2066	2028	1989
52	2430	2388	2346	2305	2264	2224	2184	2144	2105	2066	2027	1989
53	2429	2387	2346	2304	2264	2223	2183	2143	2104	2065	2026	1988
54	2429	2387	2345	2304	2263	2223	2182	2143	2103	2064	2026	1987
55	2428	2386	2344	2303	2262	2222	2182	2142	2103	2064	2025	1987
56	2427	2385	2344	2302	2262	2221	2181	2141	2102	2063	2024	1986
57	2426	2384	2343	2302	2261	2220	2180	2141	2101	2062	2024	1986
58	2426	2384	2342	2301	2260	2220	2180	2140	2101	2062	2023	1985
59	2425	2383	2341	2300	2260	2219	2179	2139	2100	2061	2023	1984

TABLE XXIX.

Proportional Logarithms.

s.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
//	1°54′	1°55′	1°56′	1°57′	1°58′	1°59′	2° 0′	2° 1′	2° 2′	2° 3′	2° 4′
0	1984	1946	1908	1871	1834	1797	1761	1725	1689	1654	1619
1	1983	1945	1907	1870	1833	1797	1760	1724	1688	1653	1618
2	1982	1944	1907	1870	1833	1796	1760	1724	1688	1652	1617
3	1982	1944	1906	1869	1832	1795	1759	1723	1687	1652	1617
4	1981	1943	1906	1868	1831	1795	1758	1722	1687	1651	1616
5	1980	1943	1905	1868	1831	1794	1758	1722	1686	1651	1616
6	1980	1942	1904	1867	1830	1794	1757	1721	1686	1650	1615
7	1979	1941	1904	1867	1830	1793	1757	1721	1685	1650	1614
8	1979	1941	1903	1866	1829	1792	1756	1720	1684	1649	1614
9	1978	1940	1903	1865	1828	1792	1755	1719	1684	1648	1613
10	1977	1939	1902	1865	1828	1791	1755	1719	1683	1648	1613
11	1977	1939	1901	1864	1827	1791	1754	1718	1683	1647	1612
12	1976	1938	1901	1863	1827	1790	1754	1718	1682	1647	1612
13	1975	1938	1900	1863	1826	1789	1753	1717	1681	1646	1611
14	1975	1937	1899	1862	1825	1789	1752	1716	1681	1645	1610
15	1974	1936	1899	1862	1825	1788	1752	1716	1680	1645	1610
16	1973	1936	1898	1861	1824	1787	1751	1715	1680	1644	1609
17	1973	1935	1898	1860	1823	1787	1751	1715	1679	1644	1609
18	1972	1934	1897	1860	1823	1786	1750	1714	1678	1643	1608
19	1972	1934	1896	1859	1822	1786	1749	1713	1678	1642	1607
20	1971	1933	1896	1858	1822	1785	1749	1713	1677	1642	1607
21	1970	1933	1895	1858	1821	1785	1748	1712	1677	1641	1606
22	1970	1932	1894	1857	1820	1784	1748	1712	1676	1641	1606
23	1969	1931	1894	1857	1820	1783	1747	1711	1675	1640	1605
24	1968	1931	1893	1856	1819	1783	1746	1711	1675	1640	1605
25	1968	1930	1893	1855	1819	1782	1746	1710	1674	1639	1604
26	1967	1929	1892	1855	1818	1781	1745	1709	1674	1638	1603
27	1967	1929	1891	1854	1817	1781	1745	1709	1673	1638	1603
28	1966	1928	1891	1854	1817	1780	1744	1708	1673	1637	1602
29	1965	1927	1890	1853	1816	1780	1743	1708	1672	1637	1602
30	1965	1927	1889	1852	1816	1779	1743	1707	1671	1636	1601
31	1964	1926	1889	1852	1815	1778	1742	1706	1671	1635	1600
32	1963	1926	1888	1851	1814	1778	1742	1706	1670	1635	1600
33	1963	1925	1888	1850	1814	1777	1741	1705	1670	1634	1599
34	1962	1924	1887	1850	1813	1777	1740	1705	1669	1634	1599
35	1961	1924	1886	1849	1812	1776	1740	1704	1668	1633	1598
36	1961	1923	1886	1849	1812	1775	1739	1703	1668	1633	1598
37	1960	1922	1885	1848	1811	1775	1739	1703	1667	1632	1597
38	1960	1922	1884	1847	1811	1774	1738	1702	1667	1631	1596
39	1959	1921	1884	1847	1810	1774	1737	1702	1666	1631	1596
40	1958	1921	1883	1846	1809	1773	1737	1701	1665	1630	1595
41	1958	1920	1883	1846	1809	1772	1736	1700	1665	1630	1595
42	1957	1919	1882	1845	1808	1772	1736	1700	1664	1629	1594
43	1956	1919	1881	1844	1808	1771	1735	1699	1664	1628	1593
44	1956	1918	1881	1844	1807	1771	1734	1699	1663	1628	1593
45	1955	1918	1880	1843	1806	1770	1734	1698	1663	1627	1592
46	1955	1917	1879	1842	1806	1769	1733	1697	1662	1627	1592
47	1954	1916	1879	1842	1805	1769	1733	1697	1661	1626	1591
48	1953	1916	1878	1841	1805	1768	1732	1696	1661	1626	1591
49	1953	1915	1878	1841	1804	1768	1731	1696	1660	1625	1590
50	1952	1914	1877	1840	1803	1767	1731	1695	1660	1624	1589
51	1951	1914	1876	1839	1803	1766	1730	1694	1659	1624	1589
52	1951	1913	1876	1839	1802	1766	1730	1694	1658	1623	1588
53	1950	1912	1875	1838	1801	1765	1729	1693	1658	1623	1588
54	1950	1912	1875	1838	1801	1765	1728	1693	1657	1622	1587
55	1949	1911	1874	1837	1800	1764	1728	1692	1657	1621	1586
56	1948	1911	1873	1836	1800	1763	1727	1691	1656	1621	1586
57	1948	1910	1873	1836	1799	1763	1727	1691	1655	1620	1585
58	1947	1909	1872	1835	1798	1762	1726	1690	1655	1620	1585
59	1946	1909	1871	1834	1798	1761	1725	1690	1654	1619	1584

Proportional Logarithms.

s. ″	h. m. 2° 5′	h. m. 2° 6′	h. m. 2° 7′	h. m. 2° 8′	h. m. 2° 9′	h. m. 2°10′	h. m. 2°11′	h. m. 2°12′	h. m. 2°13′	h. m. 2°14	h. m. 2°15′
0	1584	1549	1515	1481	1447	1413	1380	1347	1314	1282	1249
1	1583	1548	1514	1480	1446	1413	1379	1346	1314	1281	1249
2	1582	1548	1514	1479	1446	1412	1379	1346	1313	1281	1248
3	1582	1547	1513	1479	1445	1412	1378	1345	1313	1280	1248
4	1581	1547	1512	1478	1445	1411	1378	1345	1312	1279	1247
5	1581	1546	1512	1478	1444	1410	1377	1344	1311	1279	1247
6	1580	1546	1511	1477	1443	1410	1377	1344	1311	1278	1246
7	1580	1545	1511	1477	1443	1409	1376	1343	1310	1278	1246
8	1579	1544	1510	1476	1442	1409	1376	1343	1310	1277	1245
9	1578	1544	1510	1476	1442	1408	1375	1342	1309	1277	1245
10	1578	1543	1509	1475	1441	1408	1374	1341	1309	1276	1244
11	1577	1543	1508	1474	1441	1407	1374	1341	1308	1276	1243
12	1577	1542	1508	1474	1440	1407	1373	1340	1308	1275	1243
13	1576	1542	1507	1473	1440	1406	1373	1340	1307	1275	1242
14	1575	1541	1507	1473	1439	1405	1372	1339	1307	1274	1242
15	1575	1540	1506	1472	1438	1405	1372	1339	1306	1274	1241
16	1574	1540	1506	1472	1438	1404	1371	1338	1305	1273	1241
17	1574	1539	1505	1471	1437	1404	1371	1338	1305	1272	1240
18	1573	1539	1504	1470	1437	1403	1370	1337	1304	1272	1240
19	1573	1538	1504	1470	1436	1403	1369	1337	1304	1271	1239
20	1572	1538	1503	1469	1436	1402	1369	1336	1303	1271	1239
21	1571	1537	1503	1469	1435	1402	1368	1335	1303	1270	1238
22	1571	1536	1502	1468	1434	1401	1368	1335	1302	1270	1238
23	1570	1536	1502	1468	1434	1400	1367	1334	1302	1269	1237
24	1570	1535	1501	1467	1433	1400	1367	1334	1301	1269	1237
25	1569	1535	1500	1466	1433	1399	1366	1333	1301	1268	1236
26	1569	1534	1500	1466	1432	1399	1366	1333	1300	1268	1235
27	1568	1534	1499	1465	1432	1398	1365	1332	1300	1267	1235
28	1567	1533	1499	1465	1431	1398	1365	1332	1299	1267	1234
29	1567	1532	1498	1464	1431	1397	1364	1331	1298	1266	1234
30	1566	1532	1498	1464	1430	1397	1363	1331	1298	1266	1233
31	1566	1531	1497	1463	1429	1396	1363	1330	1297	1265	1233
32	1565	1531	1496	1463	1429	1395	1362	1329	1297	1264	1232
33	1565	1530	1496	1462	1428	1395	1362	1329	1296	1264	1232
34	1564	1529	1495	1461	1428	1394	1361	1328	1296	1263	1231
35	1563	1529	1495	1461	1427	1394	1361	1328	1295	1263	1231
36	1563	1528	1494	1460	1427	1393	1360	1327	1295	1262	1230
37	1562	1528	1494	1460	1426	1393	1360	1327	1294	1262	1230
38	1562	1527	1493	1459	1426	1392	1359	1326	1294	1261	1229
39	1561	1527	1493	1459	1425	1392	1359	1326	1293	1261	1229
40	1560	1526	1492	1458	1424	1391	1358	1325	1292	1260	1228
41	1560	1525	1491	1457	1424	1390	1357	1325	1292	1260	1227
42	1559	1525	1491	1457	1423	1390	1357	1324	1291	1259	1227
43	1559	1524	1490	1456	1423	1389	1356	1323	1291	1258	1226
44	1558	1524	1490	1456	1422	1389	1356	1323	1290	1258	1226
45	1558	1523	1489	1455	1422	1388	1355	1322	1290	1257	1225
46	1557	1523	1489	1455	1421	1388	1355	1322	1289	1257	1225
47	1556	1522	1488	1454	1420	1387	1354	1321	1289	1256	1224
48	1556	1522	1487	1454	1420	1387	1354	1321	1288	1256	1224
49	1555	1521	1487	1453	1419	1386	1353	1320	1288	1255	1223
50	1555	1520	1486	1452	1419	1386	1352	1320	1287	1255	1223
51	1554	1520	1486	1452	1418	1385	1352	1319	1287	1254	1222
52	1554	1519	1485	1451	1418	1384	1351	1319	1286	1254	1222
53	1553	1518	1485	1451	1417	1384	1351	1318	1285	1253	1221
54	1552	1518	1484	1450	1417	1383	1350	1317	1285	1253	1221
55	1552	1518	1483	1450	1416	1383	1350	1317	1284	1252	1220
56	1551	1517	1483	1449	1415	1382	1349	1316	1284	1251	1219
57	1551	1516	1482	1449	1415	1382	1349	1316	1283	1251	1219
58	1550	1516	1482	1448	1414	1381	1348	1315	1283	1250	1218
59	1550	1515	1481	1447	1414	1381	1347	1315	1282	1250	1218

TABLE XXIX.

Proportional Logarithms.

s.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
//	2°16′	2°17′	2°18′	2°19′	2°20′	2°21′	2°22′	2°23′	2°24′	2°25′	2°26′
0	1217	1186	1154	1123	1091	1061	1030	0999	0969	0939	0909
1	1217	1185	1153	1122	1091	1060	1029	0999	0969	0939	0909
2	1216	1184	1153	1121	1090	1059	1029	0998	0968	0938	0908
3	1216	1184	1152	1121	1090	1059	1028	0998	0968	0938	0908
4	1215	1183	1152	1120	1089	1058	1028	0997	0967	0937	0907
5	1215	1183	1151	1120	1089	1058	1027	0997	0967	0937	0907
6	1214	1182	1151	1119	1088	1057	1027	0996	0966	0936	0906
7	1214	1182	1150	1119	1088	1057	1026	0996	0966	0936	0906
8	1213	1181	1150	1118	1087	1056	1026	0995	0965	0935	0905
9	1213	1181	1149	1118	1087	1056	1025	0995	0965	0935	0905
10	1212	1180	1149	1117	1086	1055	1025	0994	0964	0934	0904
11	1211	1180	1148	1117	1086	1055	1024	0994	0964	0934	0904
12	1211	1179	1148	1116	1085	1054	1024	0993	0963	0933	0903
13	1210	1179	1147	1116	1085	1054	1023	0993	0963	0933	0903
14	1210	1178	1147	1115	1084	1053	1023	0992	0962	0932	0902
15	1209	1178	1146	1115	1084	1053	1022	0992	0962	0932	0902
16	1209	1177	1146	1114	1083	1052	1022	0991	0961	0931	0901
17	1208	1177	1145	1114	1083	1052	1021	0991	0961	0931	0901
18	1208	1176	1145	1113	1082	1051	1021	0990	0960	0930	0900
19	1207	1175	1144	1113	1082	1051	1020	0990	0960	0930	0900
20	1207	1175	1143	1112	1081	1050	1020	0989	0959	0929	0899
21	1206	1174	1143	1112	1081	1050	1019	0989	0959	0929	0899
22	1206	1174	1142	1111	1080	1049	1019	0988	0958	0928	0898
23	1205	1173	1142	1111	1080	1049	1018	0988	0958	0928	0898
24	1205	1173	1141	1110	1079	1048	1018	0987	0957	0927	0897
25	1204	1172	1141	1110	1079	1048	1017	0987	0957	0927	0897
26	1203	1172	1140	1109	1078	1047	1017	0986	0956	0926	0896
27	1203	1171	1140	1109	1078	1047	1016	0986	0956	0926	0896
28	1202	1171	1139	1108	1077	1046	1016	0985	0955	0925	0895
29	1202	1170	1139	1107	1076	1046	1015	0985	0955	0925	0895
30	1201	1170	1138	1107	1076	1045	1015	0984	0954	0924	0894
31	1201	1169	1138	1106	1075	1045	1014	0984	0954	0924	0894
32	1200	1169	1137	1106	1075	1044	1014	0983	0953	0923	0893
33	1200	1168	1137	1105	1074	1044	1013	0983	0953	0923	0893
34	1199	1168	1136	1105	1074	1043	1013	0982	0952	0922	0892
35	1199	1167	1136	1104	1073	1043	1012	0982	0952	0922	0892
36	1198	1167	1135	1104	1073	1042	1012	0981	0951	0921	0891
37	1198	1166	1135	1103	1072	1042	1011	0981	0951	0921	0891
38	1197	1165	1134	1103	1072	1041	1010	0980	0950	0920	0890
39	1197	1165	1134	1102	1071	1041	1010	0980	0950	0920	0890
40	1196	1164	1133	1102	1071	1040	1009	0979	0949	0919	0889
41	1196	1164	1132	1101	1070	1039	1009	0979	0949	0919	0889
42	1195	1163	1132	1101	1070	1039	1008	0978	0948	0918	0888
43	1194	1163	1131	1100	1069	1038	1008	0978	0948	0918	0888
44	1194	1162	1131	1100	1069	1038	1007	0977	0947	0917	0887
45	1193	1162	1130	1099	1068	1037	1007	0977	0947	0917	0887
46	1193	1161	1130	1099	1068	1037	1006	0976	0946	0916	0886
47	1192	1161	1129	1098	1067	1036	1006	0976	0946	0916	0886
48	1192	1160	1129	1098	1067	1036	1005	0975	0945	0915	0885
49	1191	1160	1128	1097	1066	1035	1005	0975	0945	0915	0885
50	1191	1159	1128	1097	1066	1035	1004	0974	0944	0914	0884
51	1190	1159	1127	1096	1065	1034	1004	0974	0944	0914	0884
52	1190	1158	1127	1096	1065	1034	1003	0973	0943	0913	0883
53	1189	1158	1126	1095	1064	1033	1003	0973	0943	0913	0883
54	1189	1157	1126	1095	1064	1033	1002	0972	0942	0912	0882
55	1188	1157	1125	1094	1063	1032	1002	0972	0942	0912	0882
56	1188	1156	1125	1093	1063	1032	1001	0971	0941	0911	0881
57	1187	1156	1124	1093	1062	1031	1001	0971	0941	0911	0881
58	1187	1155	1124	1092	1062	1031	1000	0970	0940	0910	0880
59	1186	1154	1123	1092	1061	1030	1000	0970	0940	0910	0880

Proportional Logarithms.

s.	h. m. 2°27′	h. m. 2°28′	h. m. 2°29′	h. m. 2°30′	h. m. 2°31′	h. m. 2°32′	h. m. 2°33′	h. m. 2°34′	h. m. 2°35′	h. m. 2°36′	h. m. 2°37′
0	0880	0850	0821	0792	0763	0734	0706	0678	0649	0621	0594
1	0879	0850	0820	0791	0762	0734	0705	0677	0649	0621	0593
2	0879	0849	0820	0791	0762	0733	0705	0677	0648	0621	0593
3	0878	0849	0819	0790	0762	0733	0704	0676	0648	0620	0592
4	0878	0848	0819	0790	0761	0732	0704	0676	0648	0620	0592
5	0877	0848	0818	0789	0761	0732	0703	0675	0647	0619	0591
6	0877	0847	0818	0789	0760	0731	0703	0675	0647	0619	0591
7	0876	0847	0817	0788	0760	0731	0702	0674	0646	0618	0590
8	0876	0846	0817	0788	0759	0730	0702	0674	0646	0618	0590
9	0875	0846	0816	0787	0759	0730	0702	0673	0645	0617	0590
10	0875	0845	0816	0787	0758	0729	0701	0673	0645	0617	0589
11	0874	0845	0815	0787	0758	0729	0701	0672	0644	0616	0589
12	0874	0844	0815	0786	0757	0729	0700	0672	0644	0616	0588
13	0873	0844	0815	0786	0757	0728	0700	0671	0643	0615	0588
14	0873	0843	0814	0785	0756	0728	0699	0671	0643	0615	0587
15	0872	0843	0814	0785	0756	0727	0699	0670	0642	0615	0587
16	0872	0842	0813	0784	0755	0727	0698	0670	0642	0614	0586
17	0871	0842	0813	0784	0755	0726	0698	0669	0641	0614	0586
18	0871	0841	0812	0783	0754	0726	0697	0669	0641	0613	0585
19	0870	0841	0812	0783	0754	0725	0697	0669	0641	0613	0585
20	0870	0840	0811	0782	0753	0725	0696	0668	0640	0612	0584
21	0869	0840	0811	0782	0753	0724	0696	0668	0640	0612	0584
22	0869	0839	0810	0781	0752	0724	0695	0667	0639	0611	0584
23	0868	0839	0810	0781	0752	0723	0695	0667	0639	0611	0583
24	0868	0838	0809	0780	0751	0723	0694	0666	0638	0610	0583
25	0867	0838	0809	0780	0751	0722	0694	0666	0638	0610	0582
26	0867	0837	0808	0779	0750	0722	0693	0665	0637	0609	0582
27	0866	0837	0808	0779	0750	0721	0693	0665	0637	0609	0581
28	0866	0836	0807	0778	0750	0721	0693	0664	0636	0608	0581
29	0865	0836	0807	0778	0749	0720	0692	0664	0636	0608	0580
30	0865	0835	0806	0777	0749	0720	0692	0663	0635	0608	0580
31	0864	0835	0806	0777	0748	0720	0691	0663	0635	0607	0579
32	0864	0834	0805	0776	0748	0719	0691	0662	0634	0607	0579
33	0863	0834	0805	0776	0747	0719	0690	0662	0634	0606	0579
34	0863	0833	0804	0775	0747	0718	0690	0662	0634	0606	0578
35	0862	0833	0804	0775	0746	0718	0689	0661	0633	0605	0578
36	0862	0833	0803	0774	0746	0717	0689	0661	0633	0605	0577
37	0861	0832	0803	0774	0745	0717	0688	0660	0632	0604	0577
38	0861	0832	0802	0773	0745	0716	0688	0660	0632	0604	0576
39	0860	0831	0802	0773	0744	0716	0687	0659	0631	0603	0576
40	0860	0831	0801	0773	0744	0715	0687	0659	0631	0603	0575
41	0859	0830	0801	0772	0743	0715	0686	0658	0630	0602	0575
42	0859	0830	0801	0772	0743	0714	0686	0658	0630	0602	0574
43	0858	0829	0800	0771	0742	0714	0685	0657	0629	0602	0574
44	0858	0829	0800	0771	0742	0713	0685	0657	0629	0601	0573
45	0857	0828	0799	0770	0741	0713	0685	0656	0628	0601	0573
46	0857	0828	0799	0770	0741	0712	0684	0656	0628	0600	0573
47	0856	0827	0798	0769	0740	0712	0684	0655	0627	0600	0572
48	0856	0827	0798	0769	0740	0711	0683	0655	0627	0599	0572
49	0855	0826	0797	0768	0739	0711	0683	0655	0627	0599	0571
50	0855	0826	0797	0768	0739	0711	0682	0654	0626	0598	0571
51	0855	0825	0796	0767	0739	0710	0682	0654	0626	0598	0570
52	0854	0825	0796	0767	0738	0710	0681	0653	0625	0597	0570
53	0854	0824	0795	0766	0738	0709	0681	0653	0625	0597	0569
54	0853	0824	0795	0766	0737	0709	0680	0652	0624	0596	0569
55	0853	0823	0794	0765	0737	0708	0680	0652	0624	0596	0568
56	0852	0823	0794	0765	0736	0708	0679	0651	0623	0596	0568
57	0852	0822	0793	0764	0736	0707	0679	0651	0623	0595	0568
58	0851	0822	0793	0764	0735	0707	0678	0650	0622	0595	0567
59	0851	0821	0792	0763	0735	0706	0678	0650	0622	0594	0567

TABLE XXIX.

Proportional Logarithms.

s. /	h. m. 2°38′	h. m. 2°39′	h. m. 2°40′	h. m. 2°41′	h. m. 2°42′	h. m. 2°43′	h. m. 2°44′	h. m. 2°45′	h. m. 2°46′	h. m. 2°47′	h. m. 2°48′
0	0566	0539	0512	0484	0458	0431	0404	0378	0352	0326	0300
1	0566	0538	0511	0484	0457	0430	0404	0377	0351	0325	0299
2	0565	0538	0511	0484	0457	0430	0403	0377	0351	0325	0299
3	0565	0537	0510	0483	0456	0430	0403	0377	0350	0324	0298
4	0564	0537	0510	0483	0456	0429	0402	0376	0350	0324	0298
5	0564	0536	0509	0482	0455	0429	0402	0376	0349	0323	0297
6	0563	0536	0509	0482	0455	0428	0402	0375	0349	0323	0297
7	0563	0536	0508	0481	0454	0428	0401	0375	0349	0322	0297
8	0562	0535	0508	0481	0454	0427	0401	0374	0348	0322	0296
9	0562	0535	0507	0480	0454	0427	0400	0374	0348	0322	0296
10	0562	0534	0507	0480	0453	0426	0400	0373	0347	0321	0295
11	0561	0534	0507	0479	0453	0426	0399	0373	0347	0321	0295
12	0561	0533	0506	0479	0452	0426	0399	0373	0346	0320	0294
13	0560	0533	0506	0479	0452	0425	0399	0372	0346	0320	0294
14	0560	0532	0505	0478	0451	0425	0398	0372	0346	0319	0294
15	0559	0532	0505	0478	0451	0424	0398	0371	0345	0319	0293
16	0559	0531	0504	0477	0450	0424	0397	0371	0345	0319	0293
17	0558	0531	0504	0477	0450	0423	0397	0370	0344	0318	0292
18	0558	0531	0503	0476	0450	0423	0396	0370	0344	0318	0292
19	0557	0530	0503	0476	0449	0422	0396	0370	0343	0317	0291
20	0557	0530	0502	0475	0449	0422	0395	0369	0343	0317	0291
21	0557	0529	0502	0475	0448	0422	0395	0369	0342	0316	0291
22	0556	0529	0502	0475	0448	0421	0395	0368	0342	0316	0290
23	0556	0528	0501	0474	0447	0421	0394	0368	0342	0316	0290
24	0555	0528	0501	0474	0447	0420	0394	0367	0341	0315	0289
25	0555	0527	0500	0473	0446	0420	0393	0367	0341	0315	0289
26	0554	0527	0500	0473	0446	0419	0393	0366	0340	0314	0288
27	0554	0526	0499	0472	0446	0419	0392	0366	0340	0314	0288
28	0553	0526	0499	0472	0445	0418	0392	0366	0339	0313	0288
29	0553	0526	0498	0471	0445	0418	0391	0365	0339	0313	0287
30	0552	0525	0498	0471	0444	0418	0391	0365	0339	0313	0287
31	0552	0525	0497	0471	0444	0417	0391	0364	0338	0312	0286
32	0551	0524	0497	0470	0443	0417	0390	0364	0338	0312	0286
33	0551	0524	0497	0470	0443	0416	0390	0363	0337	0311	0285
34	0551	0523	0496	0469	0442	0416	0389	0363	0337	0311	0285
35	0550	0523	0496	0469	0442	0415	0389	0363	0336	0310	0285
36	0550	0522	0495	0468	0442	0415	0388	0362	0336	0310	0284
37	0549	0522	0495	0468	0441	0414	0388	0362	0336	0310	0284
38	0549	0521	0494	0467	0441	0414	0388	0361	0335	0309	0283
39	0548	0521	0494	0467	0440	0414	0387	0361	0335	0309	0283
40	0548	0521	0493	0466	0440	0413	0387	0360	0334	0308	0282
41	0547	0520	0493	0466	0439	0413	0386	0360	0334	0308	0282
42	0547	0520	0493	0466	0439	0412	0386	0359	0333	0307	0282
43	0546	0519	0492	0465	0438	0412	0385	0359	0333	0307	0281
44	0546	0519	0492	0465	0438	0411	0385	0359	0332	0306	0281
45	0546	0518	0491	0464	0438	0411	0384	0358	0332	0306	0280
46	0545	0518	0491	0464	0437	0410	0384	0358	0332	0306	0280
47	0545	0517	0490	0463	0437	0410	0384	0357	0331	0305	0279
48	0544	0517	0490	0463	0436	0410	0383	0357	0331	0305	0279
49	0544	0516	0489	0462	0436	0409	0383	0356	0330	0304	0279
50	0543	0516	0489	0462	0435	0409	0382	0356	0330	0304	0278
51	0543	0516	0489	0462	0435	0408	0382	0356	0329	0304	0278
52	0542	0515	0488	0461	0434	0408	0381	0355	0329	0303	0277
53	0542	0515	0488	0461	0434	0407	0381	0355	0329	0303	0277
54	0541	0514	0487	0460	0434	0407	0381	0354	0328	0302	0276
55	0541	0514	0487	0460	0433	0406	0380	0354	0328	0302	0276
56	0541	0513	0486	0459	0433	0406	0380	0353	0327	0301	0276
57	0540	0513	0486	0459	0432	0406	0379	0353	0327	0301	0275
58	0540	0512	0485	0458	0432	0405	0379	0352	0326	0300	0275
59	0539	0512	0485	0458	0431	0405	0378	0352	0326	0300	0274

Proportional Logarithms.

s. ″	h. m. 2°49′	h. m. 2°50′	h. m. 2°51′	h. m. 2°52′	h. m. 2°53′	h. m. 2°54′	h. m. 2°55′	h. m. 2°56′	h. m. 2°57′	h. m. 2°58′	h. m. 2°59′
0	0274	0248	0223	0197	0172	0147	0122	0098	0073	0049	0024
1	0273	0248	0222	0197	0172	0147	0122	0097	0073	0048	0024
2	0273	0247	0222	0197	0171	0146	0121	0097	0072	0048	0023
3	0273	0247	0221	0196	0171	0146	0121	0096	0072	0047	0023
4	0272	0246	0221	0196	0171	0146	0121	0096	0071	0047	0023
5	0272	0246	0221	0195	0170	0145	0120	0096	0071	0046	0022
6	0271	0246	0220	0195	0170	0145	0120	0095	0071	0046	0022
7	0271	0245	0220	0194	0169	0144	0119	0095	0070	0046	0021
8	0270	0245	0219	0194	0169	0144	0119	0094	0070	0045	0021
9	0270	0244	0219	0194	0169	0143	0119	0094	0069	0045	0021
10	0270	0244	0218	0193	0168	0143	0118	0093	0069	0044	0020
11	0269	0244	0218	0193	0168	0143	0118	0093	0068	0044	0020
12	0269	0243	0218	0192	0167	0142	0117	0093	0068	0044	0019
13	0268	0243	0217	0192	0167	0142	0117	0092	0068	0043	0019
14	0268	0242	0217	0192	0166	0141	0117	0092	0067	0043	0018
15	0267	0242	0216	0191	0166	0141	0116	0091	0067	0042	0018
16	0267	0241	0216	0191	0166	0141	0116	0091	0066	0042	0018
17	0267	0241	0216	0190	0165	0140	0115	0091	0066	0042	0017
18	0266	0241	0215	0190	0165	0140	0115	0090	0066	0041	0017
19	0266	0240	0215	0189	0164	0139	0114	0090	0065	0041	0016
20	0265	0240	0214	0189	0164	0139	0114	0089	0065	0040	0016
21	0265	0239	0214	0189	0163	0139	0114	0089	0064	0040	0016
22	0264	0239	0213	0188	0163	0138	0113	0089	0064	0040	0015
23	0264	0238	0213	0188	0163	0138	0113	0088	0064	0039	0015
24	0264	0238	0213	0187	0162	0137	0112	0088	0063	0039	0015
25	0263	0238	0212	0187	0162	0137	0112	0087	0063	0038	0014
26	0263	0237	0212	0186	0161	0136	0112	0087	0062	0038	0014
27	0262	0237	0211	0186	0161	0136	0111	0087	0062	0038	0013
28	0262	0236	0211	0186	0161	0136	0111	0086	0062	0037	0013
29	0261	0236	0210	0185	0160	0135	0110	0086	0061	0037	0012
30	0261	0235	0210	0185	0160	0135	0110	0085	0061	0036	0012
31	0261	0235	0210	0184	0159	0134	0110	0085	0060	0036	0012
32	0260	0235	0209	0184	0159	0134	0109	0084	0060	0035	0011
33	0260	0234	0209	0184	0158	0134	0109	0084	0060	0035	0011
34	0259	0234	0208	0183	0158	0133	0108	0084	0059	0035	0010
35	0259	0233	0208	0183	0158	0133	0108	0083	0059	0034	0010
36	0258	0233	0208	0182	0157	0132	0107	0083	0058	0034	0010
37	0258	0232	0207	0182	0157	0132	0107	0082	0058	0033	0009
38	0258	0232	0207	0181	0156	0131	0107	0082	0057	0033	0009
39	0257	0232	0206	0181	0156	0131	0106	0082	0057	0033	0008
40	0257	0231	0206	0181	0156	0131	0106	0081	0057	0032	0008
41	0256	0231	0205	0180	0155	0130	0105	0081	0056	0032	0008
42	0256	0230	0205	0180	0155	0130	0105	0080	0056	0031	0007
43	0255	0230	0205	0179	0154	0129	0105	0080	0055	0031	0007
44	0255	0230	0204	0179	0154	0129	0104	0080	0055	0031	0006
45	0255	0229	0204	0179	0153	0129	0104	0079	0055	0030	0006
46	0254	0229	0203	0178	0153	0128	0103	0079	0054	0030	0006
47	0254	0228	0203	0178	0153	0128	0103	0078	0054	0029	0005
48	0253	0228	0202	0177	0152	0127	0103	0078	0053	0029	0005
49	0253	0227	0202	0177	0152	0127	0102	0077	0053	0029	0004
50	0252	0227	0202	0176	0151	0126	0102	0077	0053	0028	0004
51	0252	0227	0201	0176	0151	0126	0101	0077	0052	0028	0004
52	0252	0226	0201	0176	0151	0126	0101	0076	0052	0027	0003
53	0251	0226	0200	0175	0150	0125	0100	0076	0051	0027	0003
54	0251	0225	0200	0175	0150	0125	0100	0075	0051	0027	0002
55	0250	0225	0200	0174	0149	0124	0100	0075	0051	0026	0002
56	0250	0224	0199	0174	0149	0124	0099	0075	0050	0026	0002
57	0250	0224	0199	0174	0148	0124	0099	0074	0050	0025	0001
58	0249	0224	0198	0173	0148	0123	0098	0074	0049	0025	0001
59	0249	0223	0198	0173	0148	0123	0098	0073	0049	0025	0000

TABLE XXX.

Logarithms for computing the proportional Parts of the Change of the Right Ascension, Declination, &c. of the Sun or Moon for any given Instant of Greenwich Time.

m.	h. 0	h. 1	h. 2	h. 3	h. 4	h. 5	h. 6	h. 7	h. 8	h. 9	h. 10	h. 11
0		13802	10792	9031	7782	6812	6021	5351	4771	4260	3802	3388
1	31584	13730	10756	9007	7764	6798	6009	5341	4762	4252	3795	3382
2	28573	13660	10720	8983	7746	6784	5997	5331	4753	4244	3788	3375
3	26812	13590	10685	8959	7728	6769	5985	5320	4744	4236	3781	3369
4	25563	13522	10649	8936	7710	6755	5973	5310	4735	4228	3773	3362
5	24594	13455	10615	8912	7692	6741	5961	5300	4726	4220	3766	3355
6	23802	13388	10580	8889	7674	6726	5949	5290	4717	4212	3759	3349
7	23133	13323	10546	8865	7657	6712	5937	5279	4708	4204	3752	3342
8	22553	13259	10512	8842	7639	6698	5925	5269	4700	4196	3745	3336
9	22041	13195	10478	8819	7622	6684	5913	5259	4691	4188	3738	3329
10	21584	13133	10444	8796	7604	6670	5902	5249	4682	4180	3730	3323
11	21170	13071	10411	8773	7587	6656	5890	5239	4673	4172	3723	3316
12	20792	13010	10378	8751	7570	6642	5878	5229	4664	4164	3716	3310
13	20444	12950	10345	8728	7552	6628	5867	5219	4655	4156	3709	3304
14	20122	12891	10313	8706	7535	6614	5855	5209	4646	4149	3702	3297
15	19823	12883	10280	8683	7518	6600	5843	5199	4638	4141	3695	3290
16	19542	12776	10248	8661	7501	6587	5832	5189	4629	4133	3688	3284
17	19279	12719	10216	8639	7484	6573	5820	5179	4620	4125	3681	3278
18	19031	12663	10185	8617	7468	6559	5809	5169	4611	4117	3674	3271
19	18796	12607	10154	8595	7451	6546	5797	5159	4603	4110	3667	3265
20	18573	12553	10121	8573	7434	6532	5786	5149	4594	4102	3660	3259
21	18361	12499	10091	8552	7417	6519	5774	5139	4585	4094	3653	3252
22	18159	12446	10061	8530	7401	6505	5763	5129	4577	4086	3646	3246
23	17966	12393	10030	8509	7384	6492	5752	5119	4568	4079	3639	3239
24	17781	12341	10000	8487	7368	6478	5740	5110	4559	4071	3632	3233
25	17604	12289	9970	8466	7351	6465	5729	5100	4551	4063	3625	3227
26	17434	12239	9940	8445	7335	6452	5718	5090	4542	4056	3618	3220
27	17270	12188	9911	8424	7319	6438	5707	5081	4534	4048	3611	3214
28	17112	12139	9881	8403	7302	6425	5695	5071	4525	4040	3604	3208
29	16960	12090	9852	8382	7286	6412	5684	5061	4517	4033	3597	3201
30	16812	12041	9823	8361	7270	6399	5673	5052	4508	4025	3590	3195
31	16670	11993	9794	8341	7254	6385	5662	5042	4499	4017	3583	3189
32	16532	11946	9765	8320	7238	6372	5651	5032	4490	4010	3577	3183
33	16398	11899	9737	8300	7222	6359	5640	5023	4483	4002	3570	3176
34	16269	11852	9709	8280	7206	6346	5629	5013	4474	3995	3563	3170
35	16143	11806	9680	8259	7190	6333	5618	5004	4466	3987	3556	3164
36	16021	11761	9653	8239	7175	6320	5607	4994	4457	3979	3549	3158
37	15902	11716	9625	8219	7159	6307	5596	4985	4449	3972	3542	3151
38	15786	11671	9597	8199	7143	6295	5584	4975	4440	3965	3535	3145
39	15673	11627	9570	8179	7128	6282	5573	4966	4432	3957	3529	3139
40	15563	11584	9543	8160	7112	6269	5563	4956	4424	3949	3522	3133
41	15456	11540	9516	8140	7097	6256	5552	4947	4416	3942	3515	3127
42	15351	11498	9489	8120	7081	6244	5541	4937	4407	3934	3508	3120
43	15249	11455	9462	8101	7066	6231	5531	4928	4399	3927	3502	3114
44	15149	11413	9435	8081	7051	6218	5520	4919	4390	3919	3495	3108
45	15051	11372	9409	8062	7035	6206	5509	4909	4382	3912	3488	3102
46	14956	11331	9383	8043	7020	6193	5498	4900	4374	3905	3481	3096
47	14863	11290	9357	8023	7005	6180	5488	4891	4366	3897	3475	3089
48	14771	11249	9331	8004	6990	6168	5477	4881	4357	3890	3468	3083
49	14682	11209	9305	7985	6975	6155	5467	4872	4349	3883	3461	3077
50	14594	11170	9279	7966	6960	6143	5456	4863	4341	3875	3455	3070
51	14508	11130	9254	7948	6945	6131	5445	4854	4333	3868	3448	3065
52	14424	11092	9228	7929	6930	6118	5435	4844	4325	3860	3441	3059
53	14341	11053	9203	7910	6915	6106	5424	4835	4317	3853	3435	3053
54	14260	11015	9178	7892	6900	6094	5414	4826	4308	3846	3428	3047
55	14180	10977	9153	7873	6886	6082	5403	4817	4300	3839	3421	3041
56	14102	10939	9129	7855	6871	6069	5393	4808	4292	3831	3415	3035
57	14025	10902	9104	7836	6856	6057	5382	4799	4284	3824	3408	3028
58	13949	10865	9079	7818	6842	6045	5372	4789	4276	3817	3402	3022
59	13875	10828	9055	7800	6827	6033	5362	4780	4268	3810	3395	3016

Logarithms for computing the proportional Parts of the Change of the Right Ascension, Declination, &c. of the Sun or Moon for any given Instant of Greenwich Time.

m.	h. 12	h. 13	h. 14	h. 15	h. 16	h. 17	h. 18	h. 19	h. 20	h. 21	h. 22	h. 23
0	3010	2663	2341	2041	1761	1498	1249	1015	792	580	378	185
1	3004	2657	2336	2036	1756	1493	1245	1011	788	577	375	182
2	2998	2652	2331	2032	1752	1489	1241	1007	785	573	371	179
3	2992	2646	2325	2027	1747	1485	1237	1003	781	570	368	176
4	2986	2641	2320	2022	1743	1481	1233	999	777	566	365	172
5	2980	2635	2315	2017	1739	1476	1229	996	774	563	362	169
6	2974	2629	2310	2012	1734	1472	1225	992	770	559	358	166
7	2968	2624	2305	2008	1730	1468	1221	988	767	556	355	163
8	2962	2619	2300	2003	1725	1464	1217	984	763	553	352	160
9	2957	2613	2295	1998	1720	1460	1214	980	759	549	349	157
10	2951	2608	2290	1993	1716	1455	1209	977	756	546	345	154
11	2945	2602	2284	1989	1711	1451	1205	973	752	542	342	151
12	2939	2596	2279	1984	1707	1447	1201	969	749	539	339	147
13	2933	2591	2274	1979	1703	1443	1197	965	745	535	335	144
14	2927	2586	2269	1974	1698	1439	1194	962	742	532	332	141
15	2921	2580	2264	1969	1694	1434	1189	958	738	529	329	138
16	2915	2575	2259	1965	1689	1430	1186	954	734	525	326	135
17	2909	2569	2254	1960	1685	1426	1182	950	731	522	322	132
18	2903	2564	2249	1955	1680	1422	1178	947	727	518	319	129
19	2897	2558	2244	1951	1676	1418	1174	943	724	515	316	126
20	2891	2553	2239	1946	1671	1413	1170	939	720	512	313	123
21	2886	2547	2234	1941	1667	1409	1166	935	717	508	309	119
22	2880	2542	2229	1936	1663	1405	1162	932	713	505	306	116
23	2874	2537	2224	1931	1658	1401	1158	928	709	502	303	113
24	2868	2531	2219	1927	1654	1397	1154	924	706	498	300	110
25	2862	2526	2214	1922	1649	1393	1150	920	702	495	297	107
26	2856	2520	2209	1918	1645	1388	1146	917	699	491	293	104
27	2851	2515	2204	1913	1641	1384	1142	913	695	488	290	101
28	2845	2510	2198	1908	1636	1380	1138	909	692	485	287	98
29	2839	2504	2193	1904	1632	1376	1134	906	688	481	284	95
30	2833	2499	2188	1899	1627	1372	1130	902	685	478	280	91
31	2827	2493	2184	1894	1623	1368	1127	898	681	475	277	89
32	2822	2488	2179	1890	1619	1364	1123	894	678	471	274	85
33	2816	2483	2174	1885	1614	1359	1119	891	676	468	271	82
34	2810	2478	2169	1880	1610	1355	1115	887	671	464	268	79
35	2804	2472	2164	1876	1606	1351	1111	883	667	461	264	76
36	2798	2467	2159	1871	1601	1347	1107	880	664	458	261	73
37	2793	2462	2154	1866	1597	1343	1103	876	660	454	258	70
38	2787	2456	2149	1862	1592	1339	1099	872	657	451	255	67
39	2781	2451	2144	1857	1588	1335	1095	869	653	448	252	64
40	2776	2446	2139	1852	1584	1331	1092	865	649	444	248	61
41	2770	2440	2134	1847	1579	1327	1088	861	646	441	245	58
42	2764	2435	2129	1844	1575	1322	1084	858	642	438	242	55
43	2758	2430	2124	1839	1571	1318	1080	854	639	434	239	52
44	2753	2425	2119	1834	1566	1314	1076	850	635	431	236	49
45	2747	2419	2114	1829	1562	1310	1072	847	632	428	232	46
46	2741	2414	2109	1824	1558	1306	1068	843	629	424	229	43
47	2736	2409	2104	1820	1553	1302	1064	839	625	421	226	39
48	2730	2403	2100	1816	1549	1298	1061	836	622	418	223	36
49	2724	2398	2095	1811	1545	1294	1057	832	618	414	220	33
50	2719	2393	2090	1806	1541	1290	1053	828	615	411	217	30
51	2713	2388	2085	1802	1536	1286	1049	825	611	408	213	27
52	2708	2382	2080	1797	1532	1282	1045	821	608	404	210	24
53	2702	2377	2075	1792	1528	1278	1041	817	604	401	207	21
54	2696	2372	2070	1788	1523	1274	1038	814	601	398	204	18
55	2691	2367	2065	1784	1519	1270	1034	810	597	394	201	15
56	2685	2362	2061	1779	1515	1266	1030	806	594	391	198	12
57	2679	2356	2056	1775	1511	1262	1026	803	590	388	194	09
58	2674	2351	2051	1770	1506	1257	1022	799	587	385	191	06
59	2668	2346	2046	1766	1502	1253	1019	796	584	381	188	03

TABLE XXXI.

Distances of the Moon from the Sun and fixed Stars, for September, 1823,

(extracted from the Nautical Almanack.)

Distances of ☽'s Centre from the Sun, and from Stars *east* of her.

Stars' Names.	Days.	Noon.	III^h.	VI^h.	IX^h.	Midnight.	XV^h.	XVIII^h.	XXI^h.
		D. M. S.	D. M. S.	D. M. S.	D. M. S.	D. M. S.	D. M. S.	D. M. S.	D. M. S.
The Sun.	1	46 57 13	45 14 54	43 22 28	41 49 58	40 7 22	.. .. ..	.. .. ..	.. .. ..
Antares.	7	49 17 48	47 36 1	45 54 38	44 13 49	42 33 5	40 52 54	39 13 6	37 33 42
	8	35 54 42	34 16 5	32 37 50	30 59 58	29 22 30	.. .. ..	.. .. ..	.. .. ..
α Aquilæ.	8	.. .. ..	.. .. ..	.. .. ..	.. .. ..	85 4 30	83 39 38	82 15 9	80 51 4
	9	79 27 24	78 4 9	76 41 21	75 19 0	73 57 5	72 35 38	71 14 41	69 54 14
	10	68 34 16	67 14 49	65 55 55	64 37 34	63 19 46	62 2 33	60 45 56	59 29 56
	11	58 14 32	.. .. ..	.. .. ..	.. .. ..	.. .. ..	.. .. ..	.. .. ..	.. .. ..
Fomalhaut.	11	81 19 34	79 56 33	78 33 48	77 11 18	75 49 4	74 27 7	73 5 26	71 44 1
	12	70 22 54	69 2 4	67 41 31	66 21 15	65 1 18	63 41 39	62 22 19	61 3 18
	13	59 44 38	58 26 20	57 8 24	55 50 51	54 33 41	.. .. ..	.. .. ..	.. .. ..
α Pegasi.	13	.. .. ..	.. .. ..	.. .. ..	.. .. ..	73 33 21	72 7 59	70 42 41	69 17 26
	14	67 52 16	66 27 10	65 2 8	63 37 9	62 12 14	60 47 23	59 22 35	57 57 52
	15	56 33 14	55 8 40	53 44 10	52 19 46	50 55 29	49 31 19	48 7 17	46 43 24
	16	45 19 39	.. .. ..	.. .. ..	.. .. ..	.. .. ..	.. .. ..	.. .. ..	.. .. ..
α Arietis.	16	86 23 42	84 53 59	83 24 7	81 54 6	80 23 57	78 53 39	77 23 10	75 52 32
	17	74 21 45	72 50 47	71 19 39	69 48 20	68 16 50	66 45 9	65 13 17	63 41 14
	18	62 8 59	60 36 33	59 3 56	57 31 7	55 58 6	54 24 53	52 51 29	51 17 53
	19	49 44 6	48 10 7	46 35 57	45 1 37	43 27 6	41 52 24	40 17 33	38 42 32
	20	37 7 21	.. .. ..	.. .. ..	.. .. ..	.. .. ..	.. .. ..	.. .. ..	.. .. ..
Aldebaran.	20	69 46 58	68 12 4	66 36 59	65 1 43	63 26 17	61 50 41	60 14 55	58 39 0
	21	57 2 57	55 26 45	53 50 24	52 13 57	50 37 24	49 0 44	47 23 59	45 47 11
	22	44 10 20	42 33 26	40 56 31	39 19 39	37 42 50	36 6 4	34 29 24	32 52 57
	23	31 16 47	29 40 56	28 5 27	26 30 24	24 55 50	.. .. ..	.. .. ..	.. .. ..
Pollux.	23	.. .. ..	.. .. ..	.. .. ..	.. .. ..	65 51 28	64 10 24	62 29 11	60 47 50
	24	59 6 21	57 24 44	55 43 0	54 1 9	52 19 12	50 37 8	48 54 58	47 12 42
	25	45 30 22	43 47 58	42 5 29	40 22 57	38 40 23	.. .. ..	.. .. ..	.. .. ..
Regulus.	25	.. .. ..	.. .. ..	.. .. ..	.. .. ..	75 17 43	73 33 39	71 49 26	70 5 6
	26	68 20 38	66 36 2	64 51 19	63 6 28	61 21 30	59 36 25	57 51 13	56 5 54
	27	54 20 29	52 34 58	50 49 20	49 3 36	47 17 46	.. .. ..	.. .. ..	.. .. ..
The Sun.	24	.. .. ..	.. .. ..	.. .. ..	.. .. ..	.. .. ..	.. .. ..	119 33 30	117 57 54
	25	116 22 8	114 46 12	113 10 8	111 33 55	109 57 33	108 21 3	106 44 24	105 7 37
	26	103 30 41	101 53 37	100 16 25	98 39 5	97 1 38	95 24 3	93 46 21	92 8 32
	27	90 30 35	88 52 31	87 14 21	85 36 4	83 57 41	82 19 11	80 40 35	79 1 54
	28	77 23 7	75 44 15	74 5 17	72 26 15	70 47 9	69 7 58	67 28 44	65 49 27
	29	64 10 6	62 30 42	60 51 17	59 11 50	57 32 21	55 52 51	54 13 21	52 33 52
	30	50 54 23	49 14 55	47 35 30	45 56 7	44 16 48	42 37 33	40 58 23	39 19 19

TABLE XXXI.

Distances of the Moon from the Sun and fixed Stars, for September, 1822,

(extracted from the Nautical Almanack.)

Distances of ☽'s Centre from the Sun, and from Stars *west* of her.

Stars' Names.	Days.	Noon.	III^h.	VI^h.	IX^h.	Midnight.	XV^h.	XVIII^h.	XXI^h.
		D. M. S.	D. M. S.	D. M. S.	D. M. S.	D. M. S.	D. M. S.	D. M. S.	D. M. S.
The Sun.	7	.. .. ..	.. .. ..	.. .. ..	.. .. ..	40 21 38	41 54 6	43 26 11	44 57 55
	8	46 29 17	48 0 17	49 30 54	51 1 10	52 31 4	54 0 36	55 29 46	56 58 35
	9	58 27 4	59 55 12	61 22 59	62 50 27	64 17 35	65 44 24	67 10 54	68 37 6
	10	70 3 1	71 28 38	72 53 58	74 19 1	75 43 48	77 8 20	78 32 38	79 56 41
	11	81 20 31	82 44 8	84 7 32	85 30 44	86 53 44	88 16 34	89 39 13	91 1 42
	12	92 24 2	93 46 14	95 8 17	96 30 13	97 52 2	99 13 45	100 35 21	101 56 53
	13	103 18 20	104 39 43	106 1 2	107 22 20	108 43 35	110 4 48	111 25 59	112 47 10
	14	114 8 20	115 29 31	116 50 42	118 11 55	119 33 9	120 54 25	.. .. ..	.. .. ..
Spica ♍	11	.. .. ..	.. .. ..	.. .. ..	.. .. ..	53 51 34	55 21 43	56 51 42	58 21 31
	12	59 51 12	61 20 45	62 50 10	64 19 28	65 48 39	67 17 44	68 46 45	70 15 41
	13	71 44 32	73 13 19	74 42 4	76 10 47	77 39 27	.. .. ..	.. .. ..	.. .. ..
Antares.	13	.. .. ..	.. .. ..	.. .. ..	.. .. ..	31 52 15	33 21 0	34 49 45	36 18 29
	14	37 47 14	39 16 0	40 44 46	42 13 35	43 42 26	45 11 19	46 40 16	48 9 16
	15	49 38 21	51 7 31	52 36 46	54 6 6	55 35 33	57 5 6	58 34 46	60 4 33
	16	61 34 28	63 4 31	64 34 42	66 5 2	67 35 31	69 6 9	70 36 58	72 7 57
	17	73 39 6	75 10 26	76 41 56	78 13 37	79 45 30	81 17 35	82 49 51	84 22 19
	18	85 54 59	87 27 51	89 0 56	90 34 14	92 7 44	93 41 27	95 15 23	96 49 32
	19	98 23 54	.. .. ..	.. .. ..	.. .. ..	.. .. ..	.. .. ..	.. .. ..	.. .. ..
α Aquilæ.	19	50 31 43	51 45 55	53 1 1	54 17 1	55 33 52	56 51 32	58 9 57	59 29 6
	20	60 48 56	62 9 24	63 30 29	64 52 10	66 14 23	67 37 7	69 0 21	70 24 2
	21	71 48 9	.. .. ..	.. .. ..	.. .. ..	.. .. ..	.. .. ..	.. .. ..	.. .. ..
Fomalhaut.	21	46 51 59	48 13 50	49 36 34	51 0 8	52 24 30	53 49 37	55 15 26	56 41 55
	22	58 9 2	59 36 43	61 4 56	62 33 40	64 2 54	65 32 35	67 2 41	68 33 11
	23	70 4 5	71 35 20	73 6 55	74 38 49	76 11 1	77 43 30	79 16 15	80 49 15
	24	82 22 28	.. .. ..	.. .. ..	.. .. ..	.. .. ..	.. .. ..	.. .. ..	.. .. ..
α Pegasi.	24	60 34 18	62 12 5	63 50 9	65 28 29	67 7 5	68 45 56	70 25 2	72 4 22
	25	73 43 55	75 23 41	77 3 38	78 43 47	80 24 7	.. .. ..	.. .. ..	.. .. ..
α Arietis.	25	.. .. ..	.. .. ..	.. .. ..	.. .. ..	37 9 47	38 53 0	40 36 25	42 20 2
	26	44 3 50	45 47 49	47 31 59	49 16 20	51 0 51	52 45 30	54 30 19	56 15 16
	27	58 0 22	59 45 36	61 30 58	63 16 28	65 2 6	66 47 51	68 33 43	70 19 42
	28	72 5 48	73 52 0	75 38 17	77 24 40	79 11 8	.. .. ..	.. .. ..	.. .. ..
Aldebaran.	28	.. .. ..	.. .. ..	.. .. ..	.. .. ..	47 9 47	48 54 15	50 38 54	52 23 44
	29	54 8 44	55 53 53	57 39 11	59 24 36	61 10 8	62 55 45	64 41 27	66 27 14
	30	68 13 4	69 58 57	71 44 52	73 30 49	75 16 46	77 2 43	78 48 40	80 34 35
	01	82 20 28	.. .. ..	.. .. ..	.. .. ..	.. .. ..	.. .. ..	.. .. ..	.. .. ..

TABLE XXXII. Right Ascension, Declination, &c. of the

Days.	☽'s Mer. Passage.	Moon's Noon.	Moon's IIIh.	Moon's VIh.	Moon's IXh.
	h. m.	° ′ ″	° ′ ″	° ′ ″	° ′ ″
1	21 44	22 18 43N	21 51 12N	21 22 22N	20 52 11N
2	22 39	18 3 5	17 25 57	16 47 51	16 8 45
3	23 32	12 40 41	11 56 55	11 12 36	10 27 44
4	♂	6 36 50	5 49 42N	5 2 25N	4 14 49N
5	0 23	0 17 0N	0 30 26s	1 17 40s	2 4 43s
6	1 12	5 55 38s	6 40 41	7 25 15	8 9 10
7	2 1	11 41 6	12 21 32	13 1 14	13 40 12
8	2 50	16 43 4	17 17 4	17 50 9	18 22 18
9	3 40	20 48 33	21 14 45	21 39 53	22 3 57
10	4 32	23 47 58	24 5 24	24 21 42	24 36 51
11	5 23	25 35 15	25 43 25	25 50 25	25 56 16
12	6 15	26 7 57	26 6 49	26 4 32	26 1 8
13	7 6	25 27 23	25 17 21	25 6 17	24 54 9
14	7 54	23 38 9	23 20 0	23 0 55	22 40 54
15	8 41	20 47 21	20 22 5	19 56 0	19 29 9
16	9 27	17 3 32	16 32 17	16 0 24	15 27 52
17	10 10	12 36 10	12 0 10	11 23 43	10 46 43
18	10 53	7 35 15	6 55 48	6 16 2	5 35 57
19	11 37	2 11 34s	1 30 4s	0 48 26s	0 6 41s
20	12 21	3 23 4N	4 5 1N	4 46 53N	5 28 39N
21	13 7	8 55 8	9 35 44	10 16 0	10 55 55
22	13 56	14 9 13	14 46 22	15 22 54	15 58 47
23	14 48	18 47 36	19 18 58	19 49 23	20 18 53
24	15 45	22 31 5	22 54 12	23 15 5	23 36 44
25	16 44	25 0 29	25 13 6	25 24 16	25 35 58
26	17 45	25 59 55	26 0 21	25 59 29	25 56 55
27	18 45	25 20 44	25 8 49	24 55 25	24 40 30
28	19 44	23 4 4	22 40 34	22 15 46	21 49 41
29	20 39	19 20 51	18 47 40	18 13 30	17 38 19
30	21 31	14 28 42N	13 48 21N	13 7 20N	12 25 37N

Days.	☽'s Age.	Moon's Right Noon.	Moon's Right IIIh.	Moon's Right VIh.	Moon's Right IXh.
		h. m. s.	h. m. s.	h. m. s.	h. m. s.
1	27	7 32 15	7 39 54	7 47 21	7 55 6
2	28	8 32 18	8 39 36	8 46 51	8 54 3
3	29	9 29 22	9 36 18	9 43 11	9 50 2
4	1	10 23 41	10 30 18	10 36 55	10 43 28
5	2	11 15 56	11 22 22	11 28 47	11 35 11
6	3	12 7 2	12 13 23	12 19 43	12 26 4
7	4	12 57 49	13 4 11	13 10 34	13 16 59
8	5	13 49 2	13 55 29	14 1 57	14 8 27
9	6	14 41 5	14 47 40	14 54 15	15 0 51
10	7	15 34 3	15 40 44	15 47 24	15 54 6
11	8	16 27 38	16 34 20	16 41 3	16 47 46
12	9	17 21 13	17 27 52	17 34 31	17 41 9
13	10	18 14 3	18 20 35	18 27 4	18 33 33
14	11	19 5 32	19 11 51	19 18 8	19 24 24
15	12	19 55 16	20 1 22	20 7 25	20 13 28
16	13	20 43 14	20 49 7	20 54 59	21 0 49
17	14	21 29 43	21 35 26	21 41 9	21 46 51
18	15	22 15 12	22 20 52	22 26 30	22 32 9
19	16	23 0 25	23 6 6	23 11 47	23 17 28
20	17	23 46 9	23 51 56	23 57 45	0 3 36
21	18	0 33 15	0 39 17	0 45 21	0 51 27
22	19	1 22 36	1 28 58	1 35 23	1 41 51
23	20	2 14 57	2 21 44	2 28 35	2 35 28
24	21	3 10 44	3 17 57	3 25 12	3 32 31
25	22	4 9 47	4 17 22	4 24 59	4 32 37
26	23	5 11 13	5 19 0	5 26 47	5 34 34
27	24	6 13 27	6 21 14	6 28 58	6 36 40
28	25	7 14 46	7 22 14	7 29 47	7 37 13
29	26	8 13 51	8 21 2	8 28 11	8 35 18
30	27	9 10 10	9 17 2	9 23 50	9 30 36

Declination, September, 1823.					☽'s Semidr.	
Days.	Midnight	XV h.	XVIII h.	XXI h.	Noon.	Midnight.
	° ′ ″	° ′ ″	° ′ ″	° ′ ″	′ ″	′ ″
1	20 20 44 N	19 48 1 N	19 14 10 N	18 39 12 N	16 23	16 25
2	15 28 41	14 47 48	14 6 11	13 23 48	16 26	16 26
3	9 42 19	8 56 28	8 10 15	7 23 43	16 25	16 23
4	3 27 24 N	2 39 48 N	1 52 12 N	1 4 36 N	16 20	16 16
5	2 51 33 S	3 38 6 S	4 24 18 S	5 10 9 S	16 12	16 7
6	8 52 52	9 36 47	10 19 29	11 0 54	16 1	15 54
7	14 18 25	14 55 50	15 32 25	16 8 10	15 47	15 41
8	18 53 32	19 23 47	19 53 2	20 21 18	15 34	15 27
9	22 26 58	22 48 54	23 9 41	23 29 24	15 20	15 14
10	24 50 52	25 3 42	25 15 23	25 25 54	15 9	15 3
11	26 0 56	26 4 25	26 6 45	26 7 56	14 59	14 55
12	25 56 36	25 50 56	25 44 10	25 36 20	14 52	14 49
13	24 40 58	24 26 45	24 11 32	23 55 21	14 47	14 46
14	22 19 57	21 58 6	21 35 33	21 11 48	14 46	14 46
15	19 1 30	18 33 5	18 3 57	17 34 6	14 46	14 48
16	14 54 42	14 20 56	13 46 36	13 11 40	14 50	14 52
17	10 9 16	9 31 22	8 53 4	8 14 21	14 55	14 58
18	4 55 34 S	4 14 54 S	3 34 1 S	2 52 54 S	15 2	15 6
19	0 35 11 N	1 17 8 N	1 59 6 N	2 41 5 N	15 10	15 14
20	6 10 19	6 51 50	7 33 9	8 14 15	15 18	15 23
21	11 35 29	12 14 38	12 53 19	13 31 30	15 27	15 31
22	16 34 3	17 8 36	17 42 23	18 15 22	15 35	15 39
23	20 47 26	21 14 58	21 41 26	22 6 48	15 43	15 47
24	23 56 9	24 14 16	24 31 2	24 46 26	15 50	15 54
25	25 42 13	25 48 56	25 54 7	25 57 47	15 57	15 59
26	26 52 49	25 47 8	25 39 53	25 31 5	16 2	16 4
27	24 24 6	24 6 12	23 46 54	23 26 11	16 6	16 8
28	21 22 18	20 53 40	20 23 53	19 52 57	16 10	16 11
29	17 2 8	16 25 2	15 47 5	15 8 19	16 12	16 12
30	11 43 18 N	11 0 22 N	10 16 59 N	9 33 6 N	16 12	16 11

Ascension in Time, September, 1823.					☽'s Hl. Px.	
Days.	Midnight.	XV h.	XVIII h.	XXI h.	Noon.	Midnight.
	h. m. s.	h. m. s.	h. m. s.	h. m. s.	′ ″	′ ″
1	8 2 38	8 10 7	8 17 33	8 24 57	60 8	60 15
2	9 1 13	9 8 20	9 15 23	9 22 25	60 19	60 19
3	9 56 50	10 3 36	10 10 20	10 17 1	60 15	60 8
4	10 50 1	10 56 31	11 3 1	11 9 29	59 58	59 44
5	11 41 34	11 47 56	11 54 17	12 0 40	59 27	59 7
6	12 32 25	12 38 45	12 45 6	12 51 28	58 45	58 22
7	13 23 21	13 29 47	13 36 12	13 42 38	57 57	57 32
8	14 14 56	14 21 27	14 27 59	14 34 32	57 6	56 41
9	15 7 28	15 14 6	15 20 44	15 27 23	56 17	55 55
10	16 0 48	16 7 31	16 14 12	16 20 55	55 34	55 15
11	16 54 28	17 1 10	17 7 51	17 15 32	54 58	54 43
12	17 47 46	17 54 22	18 0 57	18 7 31	54 31	54 22
13	18 40 0	18 46 25	18 52 49	18 59 12	54 16	54 12
14	19 30 28	19 36 50	19 43 0	19 49 9	54 10	54 10
15	20 19 28	20 25 28	20 31 24	20 37 20	54 13	54 18
16	21 6 38	21 12 26	21 18 12	21 23 58	54 25	54 34
17	21 52 32	21 58 52	22 3 53	22 10 12	54 45	54 57
18	22 37 48	22 43 27	22 49 6	22 54 45	55 10	55 24
19	23 23 10	23 28 53	23 34 37	23 40 22	55 39	55 54
20	0 9 28	0 15 22	0 21 17	0 27 15	56 10	56 26
21	0 57 36	1 3 51	1 10 1	1 16 2	56 42	56 57
22	1 48 22	1 54 56	2 1 34	2 8 14	57 12	57 27
23	2 42 25	2 49 24	2 56 28	3 3 34	57 41	57 55
24	3 39 53	3 47 18	3 54 45	4 2 15	58 8	58 20
25	4 40 18	4 48 0	4 55 43	5 3 28	58 31	58 41
26	5 42 21	5 50 8	5 57 55	6 5 42	58 50	58 59
27	6 44 20	6 51 59	6 59 37	7 7 12	59 7	59 13
28	7 44 38	7 52 0	7 59 20	8 6 37	59 19	59 24
29	8 42 21	8 49 22	8 56 21	9 3 17	59 27	59 28
30	9 37 20	9 44 2	9 50 37	9 56 39	59 27	59 25

Logarithms to compute the Longitude from the Difference between the Intervals of Transit of the Moon's bright Limb and a Star.

1 Min. s	Log.	Parts.	1 Min. s	Log.	Parts.	1 Min. s	Log.	Parts.	2 Min. s	Log.	Parts
42·0	1·536442	0	48·0	1·510875	0	54·0	1·486648	0	0·0	1·463627	0
·1	1·536004	43	·1	1·510461	41	·1	1·486255	39	·1	1·463253	37
·2	1·535566	87	·2	1·510047	82	·2	1·485862	78	·2	1·462879	75
·3	1·535130	130	·3	1·509633	123	·3	1·485469	118	·3	1·462505	112
·4	1·534693	174	·4	1·509220	165	·4	1·485077	157	·4	1·462132	149
·5	1·534256	217	·5	1·508808	206	·5	1·484685	196	·5	1·461759	187
·6	1·533821	261	·6	1·508395	247	·6	1·484294	235	·6	1·461386	224
·7	1·533385	304	·7	1·507983	288	·7	1·483903	274	·7	1·461014	261
·8	1·532950	348	·8	1·507571	330	·8	1·483512	313	·8	1·460642	298
·9	1·532515	391	·9	1·507161	371	·9	1·483121	353	·9	1·460270	336
43·0	1·532081	0	49·0	1·506749	0	55·0	1·482731	0	1·0	1·459898	0
·1	1·531647	43	·1	1·506337	41	·1	1·482341	39	·1	1·459527	37
·2	1·531214	86	·2	1·505928	82	·2	1·481952	78	·2	1·459156	74
·3	1·530781	130	·3	1·505518	123	·3	1·481562	117	·3	1·458785	111
·4	1·530348	173	·4	1·505108	164	·4	1·481173	155	·4	1·458414	148
·5	1·529916	216	·5	1·504699	205	·5	1·480785	194	·5	1·458044	185
·6	1·529484	259	·6	1·504290	245	·6	1·480397	233	·6	1·457674	222
·7	1·529053	302	·7	1·503881	286	·7	1·480009	272	·7	1·457305	259
·8	1·528622	346	·8	1·503473	327	·8	1·479621	311	·8	1·456936	296
·9	1·528191	389	·9	1·503065	368	·9	1·479234	350	·9	1·456567	333
44·0	1·527761	0	50·0	1·502658	0	56·0	1·478847	0	2·0	1·456198	0
·1	1·527331	43	·1	1·502251	41	·1	1·478460	39	·1	1·455830	37
·2	1·526902	86	·2	1·501844	81	·2	1·478074	77	·2	1·455462	73
·3	1·526473	128	·3	1·501438	122	·3	1·477688	116	·3	1·455094	110
·4	1·526044	171	·4	1·501032	162	·4	1·477302	154	·4	1·454727	147
·5	1·525616	214	·5	1·500626	203	·5	1·476917	193	·5	1·454360	184
·6	1·525188	257	·6	1·500221	243	·6	1·476532	231	·6	1·453993	220
·7	1·524761	300	·7	1·499816	284	·7	1·476147	270	·7	1·453627	257
·8	1·524334	342	·8	1·499411	324	·8	1·475763	308	·8	1·453261	294
·9	1·523907	385	·9	1·499007	365	·9	1·475379	347	·9	1·452895	330
45·0	1·523481	0	51·0	1·498603	0	57·0	1·474995	0	3·0	1·452529	0
·1	1·523055	42	·1	1·498200	40	·1	1·474612	38	·1	1·452164	36
·2	1·522630	85	·2	1·497797	80	·2	1·474228	76	·2	1·451799	73
·3	1·522205	127	·3	1·497393	121	·3	1·473845	115	·3	1·451434	109
·4	1·521780	170	·4	1·496991	161	·4	1·473462	153	·4	1·451069	146
·5	1·521355	212	·5	1·496589	201	·5	1·473080	191	·5	1·450705	182
·6	1·520932	254	·6	1·496188	241	·6	1·472699	229	·6	1·450341	218
·7	1·520508	297	·7	1·495786	281	·7	1·472317	267	·7	1·449977	255
·8	1·520085	339	·8	1·495385	322	·8	1·471936	306	·8	1·449614	291
·9	1·519662	382	·9	1·494984	362	·9	1·471555	344	·9	1·449251	328
46·0	1·519240	0	52·0	1·494584	0	58·0	1·471174	0	4·0	1·448888	0
·1	1·518820	42	·1	1·494184	40	·1	1·470794	38	·1	1·448525	36
·2	1·518400	84	·2	1·493784	80	·2	1·470414	76	·2	1·448163	72
·3	1·517980	126	·3	1·493385	120	·3	1·470034	114	·3	1·447801	108
·4	1·517560	168	·4	1·492986	159	·4	1·469655	152	·4	1·447439	144
·5	1·517140	210	·5	1·492587	199	·5	1·469276	190	·5	1·447078	181
·6	1·516719	252	·6	1·492189	239	·6	1·468897	227	·6	1·446717	217
·7	1·516299	294	·7	1·491791	279	·7	1·468518	265	·7	1·446356	253
·8	1·515879	336	·8	1·491393	319	·8	1·468140	303	·8	1·445995	289
·9	1·515459	378	·9	1·490996	359	·9	1·467762	341	·9	1·445635	325
47·0	1·515039	0	53·0	1·490599	0	59·0	1·467385	0	5·0	1·445275	0
·1	1·514621	42	·1	1·490202	39	·1	1·467008	38	·1	1·444915	36
·2	1·514203	83	·2	1·489806	79	·2	1·466631	75	·2	1·444556	71
·3	1·513786	125	·3	1·489410	119	·3	1·466255	113	·3	1·444196	107
·4	1·513369	167	·4	1·489014	158	·4	1·465878	150	·4	1·443837	143
·5	1·512952	208	·5	1·488619	198	·5	1·465502	188	·5	1·443478	179
·6	1·512536	250	·6	1·488224	237	·6	1·465127	226	·6	1·443120	215
·7	1·512120	292	·7	1·487830	277	·7	1·464751	263	·7	1·442762	251
·8	1·511705	333	·8	1·487436	316	·8	1·464376	301	·8	1·442404	286
·9	1·511290	375	·9	1·487042	356	·9	1·464001	338	9	1·442046	322

Logarithms to compute the Longitude from the Difference between the Intervals of Transit of the Moon's bright Limb and a Star.

2 Min. s	Log.	Parts.	2 Min. s	Log.	Parts.	2 Min. s	Log.	Parts.	2 Min. s	Log.	Parts.
6·0	1·441689	0	12·0	1·420737	0	18·0	1·400682	0	24·0	1·381448	0
·1	1·441332	36	·1	1·420396	34	·1	1·400355	33	·1	1·381134	31
·2	1·440975	71	·2	1·420055	68	·2	1·400028	65	·2	1·380820	63
·3	1·440619	107	·3	1·419715	102	·3	1·399701	98	·3	1·380506	94
·4	1·440263	142	·4	1·419373	136	·4	1·399375	130	·4	1·380193	125
·5	1·439907	178	·5	1·419033	170	·5	1·399049	163	·5	1·379880	156
·6	1·439551	214	·6	1·418693	204	·6	1·398723	196	·6	1·379567	188
·7	1·439196	249	·7	1·418354	238	·7	1·398397	228	·7	1·379254	219
·8	1·438840	285	·8	1·418014	272	·8	1·398071	261	·8	1·378941	250
·9	1·438486	320	·9	1·417674	306	·9	1·397746	293	·9	1·378629	282
7·0	1·438131	0	13·0	1·417335	0	19·0	1·397421	0	25·0	1·378317	0
·1	1·437777	35	·1	1·416996	34	·1	1·397096	32	·1	1·378005	31
·2	1·437423	71	·2	1·416657	67	·2	1·396772	65	·2	1·377693	62
·3	1·437069	106	·3	1·416319	101	·3	1·396447	97	·3	1·377382	93
·4	1·436715	141	·4	1·415981	135	·4	1·396123	129	·4	1·377071	124
·5	1·436362	177	·5	1·415643	168	·5	1·395799	161	·5	1·376759	155
·6	1·436009	212	·6	1·415306	202	·6	1·395476	194	·6	1·376449	186
·7	1·435650	247	·7	1·414969	236	·7	1·395152	226	·7	1·376138	218
·8	1·435304	282	·8	1·414631	276	·8	1·394829	258	·8	1·375827	249
·9	1·434952	318	·9	1·414294	303	·9	1·394506	291	·9	1·375517	280
8·0	1·434600	0	14·0	1·413957	0	20·0	1·394183	0	26·0	1·375207	0
·1	1·434248	35	·1	1·413621	33	·1	1·393860	32	·1	1·374897	31
·2	1·433897	70	·2	1·413285	67	·2	1·393538	64	·2	1·374587	62
·3	1·433546	105	·3	1·412949	100	·3	1·393216	96	·3	1·374278	92
·4	1·433195	140	·4	1·412613	134	·4	1·392894	128	·4	1·373969	123
·5	1·432845	175	·5	1·412278	167	·5	1·392572	160	·5	1·373659	154
·6	1·432494	210	·6	1·411942	201	·6	1·392251	193	·6	1·373351	185
·7	1·432144	245	·7	1·411607	234	·7	1·391930	225	·7	1·373042	216
·8	1·431795	280	·8	1·411273	268	·8	1·391608	257	·8	1·372733	246
·9	1·431445	315	·9	1·410938	301	·9	1·391288	289	·9	1·372425	277
9·0	1·431096	0	15·0	1·410604	0	21·0	1·390967	0	27·0	1·372117	0
·1	1·430747	35	·1	1·410270	33	·1	1·390647	32	·1	1·371809	31
·2	1·430398	70	·2	1·409936	67	·2	1·390327	64	·2	1·371501	61
·3	1·430050	104	·3	1·409602	100	·3	1·390007	96	·3	1·371194	92
·4	1·429701	139	·4	1·409269	133	·4	1·389687	128	·4	1·370887	122
·5	1·429354	174	·5	1·408935	166	·5	1·389367	159	·5	1·370579	153
·6	1·429006	209	·6	1·408602	200	·6	1·389048	191	·6	1·370273	184
·7	1·428659	244	·7	1·408270	233	·7	1·388729	223	·7	1·369966	214
·8	1·428312	278	·8	1·407937	266	·8	1·388410	255	·8	1·369659	245
·9	1·427965	313	·9	1·407605	300	·9	1·388091	287	·9	1·369353	275
10·0	1·427618	0	16·0	1·407273	0	22·0	1·387773	0	28·0	1·369047	0
·1	1·427272	35	·1	1·406941	33	·1	1·387454	32	·1	1·368741	30
·2	1·426925	69	·2	1·406610	66	·2	1·387137	63	·2	1·368435	61
·3	1·426580	103	·3	1·406278	99	·3	1·386819	95	·3	1·368130	91
·4	1·426234	138	·4	1·405947	132	·4	1·386501	127	·4	1·367825	122
·5	1·425888	172	·5	1·405617	165	·5	1·386183	158	·5	1·367520	152
·6	1·425543	207	·6	1·405286	198	·6	1·385867	190	·6	1·367215	183
·7	1·425198	242	·7	1·404956	231	·7	1·385550	222	·7	1·366910	213
·8	1·424854	276	·8	1·404626	264	·8	1·385233	254	·8	1·366605	244
·9	1·424509	310	·9	1·404296	297	·9	1·384916	285	·9	1·366301	274
11·0	1·424165	0	17·0	1·403966	0	23·0	1·384600	0	29·0	1·365997	0
·1	1·423821	34	·1	1·403636	33	·1	1·384284	31	·1	1·365693	30
·2	1·423477	69	·2	1·403307	66	·2	1·383968	63	·2	1·365389	61
·3	1·423134	103	·3	1·402978	98	·3	1·383652	94	·3	1·365086	91
·4	1·422791	137	·4	1·402650	131	·4	1·383337	126	·4	1·364782	121
·5	1·422448	171	·5	1·402321	164	·5	1·383021	157	·5	1·364479	151
·6	1·422105	206	·6	1·401993	197	·6	1·382706	189	·6	1·364176	182
·7	1·421763	240	·7	1·401665	230	·7	1·382391	220	·7	1·363873	212
·8	1·421421	274	·8	1·401337	262	·8	1·382077	252	·8	1·363571	242
·9	1·421079	309	·9	1·401009	295	·9	1·381762	283	·9	1·363268	273

Logarithms to compute the Longitude from the Difference between the Intervals of Transit of the Moon's bright Limb and a Star.

2 Min. s	Log.	Parts.	2 Min. s	Log.	Parts.	2 Min. s	Log.	Parts.	2 Min. s	Log.	Parts
30·0	1·362966	0	34·0	1·351035	0	38·0	1·339396	0	42·0	1·328034	0
·1	1·362664	30	·1	1·350740	29	·1	1·339109	29	·1	1·327753	28
·2	1·362362	60	·2	1·350446	59	·2	1·338821	57	·2	1·327473	56
·3	1·362061	90	·3	1·350152	88	·3	1·338534	86	·3	1·327192	84
·4	1·361759	120	·4	1·349858	118	·4	1·338248	115	·4	1·326912	112
·5	1·361458	150	·5	1·349564	147	·5	1·337961	143	·5	1·326632	140
·6	1·361157	181	·6	1·349271	176	·6	1·337675	172	·6	1·326352	168
·7	1·360856	211	·7	1·348977	206	·7	1·337388	201	·7	1·326073	196
·8	1·360556	241	·8	1·348684	235	·8	1·337102	230	·8	1·325793	224
·9	1·360255	271	·9	1·348391	265	·9	1·336816	258	·9	1·325514	252
31·0	1·359955	0	35·0	1·348098	0	39·0	1·336530	0	43·0	1·325235	0
·1	1·359655	30	·1	1·347805	29	·1	1·336244	28	·1	1·324956	28
·2	1·359355	60	·2	1·347513	58	·2	1·335959	57	·2	1·324677	56
·3	1·359055	90	·3	1·347220	88	·3	1·335674	85	·3	1·324399	83
·4	1·358756	120	·4	1·346928	117	·4	1·335389	114	·4	1·324120	111
·5	1·358457	149	·5	1·346636	146	·5	1·335104	142	·5	1·323842	139
·6	1·358157	179	·6	1·346344	175	·6	1·334819	171	·6	1·323564	167
·7	1·357859	209	·7	1·346053	204	·7	1·334534	199	·7	1·323286	195
·8	1·357560	239	·8	1·345761	234	·8	1·334250	228	·8	1·323008	222
·9	1·357261	269	·9	1·345470	263	·9	1·333966	256	·9	1·322730	250
32·0	1·356963	0	36·0	1·345179	0	40·0	1·333682	0	44·0	1·322453	0
·1	1·356665	30	·1	1·344888	29	·1	1·333398	28	·1	1·322176	28
·2	1·356367	59	·2	1·344598	58	·2	1·333114	57	·2	1·321898	55
·3	1·356069	89	·3	1·344307	87	·3	1·332831	85	·3	1·321621	83
·4	1·355772	119	·4	1·344017	116	·4	1·332547	113	·4	1·321345	111
·5	1·355474	148	·5	1·343727	145	·5	1·332264	141	·5	1·321068	138
·6	1·355177	178	·6	1·343437	174	·6	1·331981	170	·6	1·320791	166
·7	1·354880	208	·7	1·343147	203	·7	1·331698	198	·7	1·320515	194
·8	1·354583	238	·8	1·342858	232	·8	1·331415	226	·8	1·320239	222
·9	1·354286	267	·9	1·342568	261	·9	1·331132	255	·9	1·319963	249
33·0	1·353990	0	37·0	1·342279	0	41·0	1·330850	0	45·0	1·319687	0
·1	1·353694	29	·1	1·341990	29	·1	1·330568	28	·1	1·319411	27
·2	1·353397	59	·2	1·341701	58	·2	1·330285	56	·2	1·319136	55
·3	1·353102	88	·3	1·341412	86	·3	1·330003	84	·3	1·318860	82
·4	1·352806	118	·4	1·341124	115	·4	1·329722	112	·4	1·318585	110
·5	1·352510	147	·5	1·340835	144	·5	1·329440	140	·5	1·318310	137
·6	1·352215	177	·6	1·340547	173	·6	1·329158	169	·6	1·318035	165
·7	1·351920	206	·7	1·340259	202	·7	1·328877	197	·7	1·317760	192
·8	1·351624	236	·8	1·339971	230	·8	1·328596	225	·8	1·317486	220
·9	1·351330	265	·9	1·339683	259	·9	1·328315	253	·9	1·317211	247

TABLE XXXIV.

Effect of a Change in the Moon's Semidiameter on the Time of its passing the Meridian.

Change of ☽'s Semid.	Moon's Declination.				
	° 0	° 8	° 16	° 22	° 28
″	s	s	s	s	s
1	·07	·07	·07	·07	·07
2	·14	·14	·14	·15	·15
3	·21	·21	·22	·23	·23
4	·28	·28	·29	·30	·31
5	·34	·35	·36	·38	·39
6	·41	·42	·43	·45	·47
7	·48	·49	·50	·53	·55
8	·55	·56	·58	·60	·62
9	·62	·63	·65	·68	·70
10	·69	·70	·72	·75	·78

TABLE XXXV.

Latitudes and Longitudes of Places, with the time of High Water at the full and change of the Moon, where it is known.

Places.	Coast, Sea, or Country.	Latitude.	Longitude.	Time H. W.
Aalborg	Denmark	57° 2′ 46″ N	9°55′ 40″ E	
Abaco Isle, N. E. Point	Lucayos	26 30 0 N	77 0 12 W	
Abbeville	France	50 7 0 N	1 50 0 W	10 30
Abbs (St.) Head	Scotland	55 55 0 N	2 8 0 W	2 30
Aberdeen, Obs.	Scotland	57 8 58 N	2 5 42 W	0 45
Abington, I. C. Ibetson	Gallepagos Isles	0 29 0 N	90 43 40 W	
Abo	Finland	60 26 58 N	22 17 9 E	
Aboukir Tower	Egypt	31 19 44 N	30 4 30 E	
Abrolhos Isles	Brazil	17 58 0 S	38 41 15 W	
Acheen Head	Sumatra	5 36 0 N	95 19 0 E	
Acre	Syria	32 54 35 N	35 3 34 E	
Admiralty Isles, Negro	Pacific Ocean	2 0 0 S	146 19 54 E	
Adventure Isle	Pacific Ocean	17 10 0 S	144 30 0 W	
African Isles, S. Isle	Indian Ocean	4 55 0 S	54 9 0 E	9 39
Afuera Isle	Pacific Ocean	33 45 0 S	80 22 0 W	
Ageroe Isle, Centre	Norway	59 2 46 N	10 54 17 E	
Agnes (St.) Isle Light	Scilly Isles	49 53 37 N	6 19 23 W	4 40
Air Light	Scotland	55 25 30 N	4 26 0 W	
Aix Isle	W. Coast of France	46 2 0 N	1 11 0 W	3 0
Ajaccio	Corsica	41 55 0 N	8 44 0 E	
Alacranes Isles, W. Island	Gulf of Mexico	22 30 0 N	89 42 0 W	
Alban's (St.) Head	England	50 32 30 N	2 5 0 W	7 30
Albany	United States	42 39 0 N	73 45 0 W	
Albany Fort	Hudson's Bay	52 14 40 N	82 0 0 W	
Albany Otway Cape	New South Wales	38 51 0 S	143 30 0 E	
Albemarle Isle, C. Berkeley	Pacific Ocean	0 2 0 N	91 31 30 W	
Alboran Isle	Mediterranean	35 57 0 N	3 1 0 W	
Aldabra Isles	Indian Ocean	9 17 0 S	46 14 0 E	
Alderney Isle, N. End	France	49 45 43 N	2 12 30 W	6 0
Aleootskia Isles, E.	Pacific Ocean	53 54 0 N	166 22 0 W	
Aleppo	Turkey in Asia	36 11 0 N	37 5 0 E	
Alexandretta	Turkey in Asia	36 35 0 N	36 15 0 E	
Alexandria	Egypt	31 13 0 N	29 53 0 E	
Algiers Light	Barbary	36 47 20 N	3 3 31 E	
Algoa Bay, C. Recife	Africa	34 1 0 S	25 40 0 E	3 20
Alicante	Spain	38 21 0 N	0 26 0 W	
Alicuri Isle, Church	Mediterranean	38 33 40 N	14 13 40 E	
Alphonse Isle	Indian Ocean	7 4 0 S	52 49 0 E	
Amag Isle Drago	Cattegate	55 35 0 N	12 41 30 E	
Amargura Isle	Friendly Isles	18 0 0 S	174 35 0 W	
Amazon R. Ent.	Guayana	1 25 0 N	50 5 0 W	6 0
Amber Cape, N. E. extreme	Madagascar	11 57 0 S	49 14 0 E	
Amblaw Isle	Indian Archipelago	3 52 0 S	127 10 0 E	
Amboyna, Fort Victoria	Indian Archipelago	3 40 0 S	128 15 0 E	
Ambrose (St.) Isle	Pacific Ocean	26 20 0 S	79 51 0 W	
Ambrym Isle	Pacific Ocean	16 9 30 S	168 12 30 E	
Amelia Isle, N. End	United States	30 40 0 N	81 35 0 W	9 0
Amirante Isles, S. Point	Indian Ocean	6 20 0 S	54 40 0 E	
Amoy Harbour, Chapel Isle	Chinese Sea	24 10 0 N	118 10 0 E	
Amphitrite Isle, N. Isle	Paracels	16 58 0 N	112 15 0 E	
Amsterdam	Netherlands	52 22 0 N	4 53 0 E	3 0
Amsterdam Isle	Indian Archipelago	0 19 30 S	132 15 0 E	
Amsterdam Isle, W. Point	Indian Ocean	37 47 46 S	77 25 11 E	
Anambas, North	Chinese Sea	3 27 0 N	106 15 0 E	
Ancona Light	Italy	43 37 42 N	13 30 35 E	
Andaman Isle, (Gt.) N. E. Point	Bay of Bengal	13 34 0 N	93 9 0 E	
Andaman Isle, (Little) S. E. Pt.	Bay of Bengal	10 26 0 N	92 40 0 E	
Andero (St.)	Spain	43 28 20 N	3 40 0 W	
Anderson's Isle	Sea of Kamschatka	63 4 0 N	167 38 0 W	
Andrew's, (St.) Cape	Madagascar	16 2 0 S	45 16 0 E	
Andrew's (St.) Isle	Carribean Sea	12 31 0 N	80 59 0 W	

TABLE XXXV.

Latitudes and Longitudes of Places, &c.

Places.	Coast, Sea, or Country.	Latitude.	Longitude.	Time H. W.
Andrew's (St.) Isles	Pacific Ocean	5°20′ 0″N	132°16′ 0″E	
Anegada Isle, S. E. Point	Carribee Isles	18 44 0 N	64 17 0 W	
Angra Pequina Harbour	Africa	26 38 24 S	15 2 30 E	
Angrias Bank	Indian Ocean	16 30 0 N	71 55 0 E	
Anguilla Isle, W. Point	Carribee Isles	18 14 30 N	63 9 36 W	
Anholt Light	Denmark	56 44 20 N	11 38 51 E	12 0
Annapolis Royal	United States	44 45 30 N	65 46 30 W	10 0
Annobona Isle, Peak	Atlantic Ocean	1 24 13 S	5 38 12 E	
Ann's (St.) Shoals, N. End	Africa	7 56 0 N	13 30 0 W	
Anthony's (St.) Isle, N.W. Point	Cape Verd Isles	17 12 0 N	25 5 0 W	
Anticosti Isle, Jupiter's Inlet	Gulf of St. Lawrence	49 26 0 N	63 38 0 W	3 30
Do. E. End	Gulf of St. Lawrence	49 9 0 N	61 55 0 W	
Antigua Isle, Fort Hamilton	Carribee Isles	17 4 30 N	61 54 45 W	
Antonio (St.) Cape	Cuba	21 54 0 N	85 1 0 W	
Antonio (St.) Cape	Paraguay	36 20 0 S	56 47 0 W	
Antonio (St.) Port	Patagonia	45 2 30 S	65 48 44 W	
Aor Isle	Indian Archipelago	2 29 30 N	104 34 0 E	
Apalache Bay	Florida	30 0 0 N	84 45 0 W	
Apee Isle	New Hebrides	16 46 30 S	168 27 30 E	
Arcas (Las) Isles, N. Isle	Gulf of Mexico	20 16 0 N	91 54 0 W	
Archangel Arsenal	Russia in Europe	64 31 40 N	40 43 39 E	6 0
Arcot Fort	India	12 54 14 N	79 21 33 E	
Arentes Isle	Indian Archipelago	5 10 0 S	114 36 0 E	
Arica	Peru	18 27 55 S	70 25 0 W	
Arklow	Ireland	52 49 0 N	6 6 30 W	8 15
Arran, N. Isle, Light	Ireland	53 8 0 N	9 35 0 W	
Arroa Isle, (Round)	Straits of Malacca	2 49 0 N	100 49 0 E	
Arroa Isle, (Great) S. Point	Indian Archipelago	7 6 0 S	135 0 0 E	
Ascension Isle	Carolinas	6 53 0 N	158 53 0 E	
Ascension Isle, Cross Hill	Atlantic Ocean	7 55 30 S	14 23 8 W	
Asia Isles, S. W. Isle	Indian Archipelago	0 57 45 N	131 7 39 E	
Aspoe Isle, N. End	Norway	61 13 0 N	4 46 0 E	
Assumption Isle	Pacific Ocean	19 45 0 N	145 35 0 E	
Assumption Isle	Indian Ocean	9 50 0 S	47 16 0 E	
Athens, Parthenon	Turkey in Europe	37 58 0 N	23 43 54 E	
Atkin's Shoal	Atlantic Ocean	55 18 0 N	11 15 0 W	
Atwood's Key, W. Point	Lucayos	23 9 10 N	73 47 40 W	
Auckland's Isles, N. Point	Pacific Ocean	50 31 0 S	166 4 0 E	
Augulhas Cape	Africa	34 51 0 S	22 17 0 E	
Augusta Light	Sicily	37 12 40 N	15 12 30 E	
Augusta Shoal	Indian Ocean	33 44 0 S	36 16 0 E	
Augustine (St.)	Florida	29 48 0 N	81 18 0 W	7 30
Augustine (St.) Bay	Labrador	51 13 0 N	58 47 0 W	
Augustine (St.) Cape	Brazil	8 23 0 S	34 56 0 W	
Aurora Isle	New Hebrides	15 8 0 S	168 17 0 E	
Aves, or Bird's Isles	Carribee Isles	15 30 0 N	63 38 0 W	
Awatska Bay	Kamschatka	52 52 0 N	158 47 0 E	4 36
Baba Cape	Turkey in Asia	39 30 15 N	25 51 40 E	
Babber Isle	Indian Archipelago	7 25 0 S	130 40 0 E	
Babelmandel Cape	Arabia	12 40 0 N	43 31 0 E	
Bahama Isle (Great) W. End	Lucayos	26 43 0 N	78 56 0 W	
Bajador Cape	Africa	26 7 30 N	14 30 10 W	0 0
Baker's Isle Light	United States	42 32 0 N	70 50 0 W	
Balade Harbour, Bouguioue Isle	New Caledonia	20 16 41 S	164 25 32 E	6 30
Balagonan Point	Mindanao	7 51 0 N	122 24 0 E	
Bald Cape	Newfoundland	51 39 45 N	55 27 35 W	
Bald Head	New Holland	35 6 15 S	118 0 45 E	
Balambangan Isle	Indian Archipelago	7 16 0 N	116 58 0 E	
Balasore	India	21 30 0 N	87 1 30 E	9 45
Bally Isle, S. Point	Indian Archipelago	8 57 0 S	115 9 0 E	

TABLE XXXV.

Latitudes and Longitudes of Places, &c.

Places.	Coast, Sea, or Country.	Latitude.	Longitude.	Time H. W.
Bal R. Entrance	Greenland	64° 9′ 55″N	51°49′ 45″W	
Baltimore	Ireland	51 27 0 N	9 20 0 W	3 45
Baltimore	United States	39 22 0 N	76 50 0 W	
Bamburgh Castle	England	55 36 42 N	1 42 8 W	
Bamff	Scotland	57 40 0 N	2 32 0 W	11 30
Bampton's Shoal, Centre	Pacific Ocean	19 9 30 S	158 23 30 E	
Banca Isle	Indian Archipelago	1 52 0 N	125 24 0 E	
Banca Isle, N. Point	Indian Archipelago	1 27 0 S	105 51 0 E	
Bancoot R. Entrance	India	17 57 0 N	73 9 0 E	11 0
Banda Isle, Anchorage	Indian Archipelago	4 31 0 S	130 0 0 E	
Banks's (Sir J.) Island	Pacific Ocean	13 27 0 S	167 24 0 E	
Bantam	Java	6 4 0 S	106 12 0 E	
Barbadoes Island, Bridgetown	Carribee Isles	13 5 0 N	59 30 24 W	
Barbadoes Island	Pacific Ocean	8 54 0 N	178 21 0 W	
Barbary Point	Africa	15 53 0 N	16 31 15 W	10 30
Barbas Cape	Africa	22 19 53 N	16 40 35 W	
Barbe (St.) Island	Indian Archipelago	0 9 0 N	107 24 0 E	
Barbuda Island	Carribee Isles	17 38 0 N	61 50 0 W	
Barcelona, New	Terra Firma	10 6 52 N	64 44 30 W	
Barcelona, Mountjoy Tower	Spain	41 21 44 N	2 9 57 E	
Barfleur Light	France	49 40 21 N	1 15 15 W	7 30
Barren Island	Bay of Bengal	12 17 0 N	93 54 0 E	
Barren Islands N.	Mozambique	18 18 0 S	46 1 0 E	
Bartholomew (St.) Island	Carribee Isles	17 53 30 N	63 0 0 W	
Baseelan Island, E. Point	Indian Archipelago	6 30 0 N	120 30 0 E	
Bashee Island, Grafton Island	Chinese Sea	21 4 0 N	121 0 15 E	
Bastia	Corsica	42 41 36 N	9 26 45 E	
Batavia Obs.	Java	6 9 0 S	106 53 21 E	
Bayonne	France	43 29 15 N	1 28 26 W	3 30
Bazaruto Isle, N. End	Mozambique	21 31 0 S	35 28 0 E	
Bear Island	James's Bay	54 34 0 N	81 24 0 W	12 0
Beconia Isle	Carribee Isles	13 1 0 N	61 16 0 W	
Bedford's Cape	Davis's Straits	66 55 0 N	68 30 0 W	
Bees (St.) Head Light	England	54 30 55 N	3 37 24 W	11 0
Behring's Isle	Sea of Kamschatka	55 36 0 N	167 46 0 E	
Belfast	Ireland	54 35 0 N	5 57 0 W	10 30
Bembridge Point	Isle of Wight	50 41 0 N	1 4 51 W	11 40
Bencoolen, Fort Marlborough	Sumatra	3 48 0 S	102 0 0 E	0 0
Benquierre, or Nelson's Island	Coast of Egypt	31 21 0 N	30 39 0 E	
Bergen Castle	Norway	60 24 0 N	5 18 6 E	1 30
Bermuda Isle, St. George	Atlantic Ocean	32 22 0 N	64 30 0 W	7 49
Bernard's (St.) Island	Friendly Isles	10 51 0 S	167 10 0 W	
Berwick-on-Tweed	Scotland	55 46 21 N	1 59 41 W	2 15
Bilboa	Spain	43 14 30 N	2 44 0 W	3 15
Billiton, N. W. Point	Chinese Sea	2 36 0 S	107 35 0 E	
Bird Island	Pacific Ocean	17 49 0 S	142 43 0 W	
Bird Island, Centre	W. Coast of Africa	24 38 0 S	15 2 30 E	
Bird Island, (Great)	S. Coast of Africa	33 52 0 S	26 6 0 E	
Bird's Isle	Sandwich Isles	23 14 0 N	162 6 0 W	
Bird's Isles	Gulf of St. Lawrence	47 55 0 N	60 46 0 W	
Blanca Island, N. Point	Carribee Sea	11 55 13 N	64 32 30 W	
Blanco Cape	Patagonia	47 15 30 S	65 57 15 W	
Blanco Cape	Africa	20 46 55 N	17 1 45 W	9 45
Blas (St.) Cape	Florida	29 41 0 N	86 2 0 W	
Block Island	United States	41 10 0 N	71 39 0 W	7 37
Bolcheritz	Kamschatka	52 54 30 N	156 50 0 E	
Bomba Island	Barbary	32 22 0 N	23 14 0 E	
Bombay Light	India	18 53 45 N	72 56 0 E	12 0
Bonacio Island, N. E. Point	Bay of Honduras	16 31 0 N	85 47 0 W	
Bonaventure Island	United States	48 33 0 N	63 48 0 W	

TABLE XXXV.

Latitudes and Longitudes of Places, &c.

Places.	Coast, Sea, or Country.	Latitude.	Longitude.	Time H.	Time W.
Bonavista Cape	Newfoundland	48°42′ 0″N	52°56′ 0″W		
Bonavista Island, N. W. Point	Cape Verd Islands	16 13 13 N	22 50 24 W		
Boo Isles	Indian Archipelago	1 12 0 S	129 18 0 E		
Borneo	Borneo	4 55 0 N	114 55 0 E		
Bornholm Island, Light	Baltic Sea	55 18 0 N	14 48 0 E		
Boscawen's Isle	Pacific Ocean	15 50 0 S	174 8 0 W		
Boston State House	United States	42 20 58 N	71 3 25 W	11	25
Botany Bay	New South Wales	34 0 0 S	151 14 0 E	8	0
Botol Tobago, Xima Island	Pacific Ocean	21 59 0 N	121 48 0 E		
Bouca Island, N. Point	Pacific Ocean	5 0 30 S	154 35 0 E		
Bounty Isles	Pacific Ocean	47 44 0 S	179 6 0 E		
Bourbon Island, St. Denys	Indian Ocean	20 52 0 S	55 26 30 E		
Bouro Island, Cajeli Bay	Indian Archipelago	3 25 0 S	127 0 0 E		
Bouton Island, E. Point	Indian Ocean	5 15 0 S	123 15 0 E		
Bouton Island, Dome	Straits of Malacca	6 33 0 N	99 20 0 E		
Bouvet's Island	Atlantic Ocean	54 16 0 S	6 14 0 E		
Bow Island, N. E. Point	Pacific Ocean	18 6 18 S	140 51 15 W		
Brava Island, S. Point	Cape Verd Isles	14 46 0 N	24 46 0 W		
Brehat Island	France	48 50 0 N	2 56 0 W	7	30
Bremen	Germany	53 5 0 N	8 48 0 E	6	0
Brest Observatory	France	48 23 32 N	4 29 25 W	4	30
Broyle Cape	Newfoundland	47 8 0 N	52 35 0 W		
Bruster Ort Lights	Prussia	54 52 0 N	19 55 0 E		
Bucarelli Point	N. W. Coast of Amer.	55 12 0 N	133 25 0 W		
Buchan Ness	Scotland	57 30 0 N	1 47 0 W	12	0
Buenos Ayres	Paraguay	34 37 0 S	58 24 30 W		
Burgeo Isles	Newfoundland	47 35 0 N	57 36 0 W		
Burlings	Portugal	39 25 0 N	9 31 0 W	3	0
Burning Island	Indian Archipelago	6 35 0 S	126 40 0 E		
Buttacoli Roads	Ceylon	7 44 0 N	81 52 0 E		
Butt of Lewis	Lewis Isles	58 29 0 N	6 12 0 W		
Button Island	Hudson's Straits	60 35 0 N	65 20 0 W	6	50
Button Ness Light	Scotland	56 28 0 N	2 45 0 W	2	0
Byam Martin Cape	Greenland	73 32 0 N	77 13 0 W		
Byron Cape	New Holland	28 38 0 S	153 37 0 E		
Cabrera Island	Mediterranean	39 7 0 N	3 0 0 E		
Cadiz Obs.	Spain	36 32 0 N	6 17 22 W	4	0
Cagayanes Isles	Philippines	9 34 0 N	121 23 0 E		
Cagayan Sooloo Island	Chinese Sea	7 0 0 N	118 36 0 E		
Cagliari	Sardinia	39 13 9 N	9 5 45 E		
Cairo, Janissary Tower	Egypt	30 2 21 N	31 15 36 E		
Calcutta, Fort William	India	22 33 11 N	88 26 17 E	3	5
Callao Port, Castle	Peru	12 3 38 S	77 14 19 W		
Calmar	Sweden	56 40 30 N	16 21 0 E		
Cambing Island, S. Point	Indian Archipelago	8 21 0 S	125 39 0 E		
Cambayna Island, Peak	Indian Archipelago	5 21 0 S	122 1 0 E		
Camarones River	W. Coast of Africa	3 45 0 N	9 35 0 E		
Campbell Cape	New Zealand	41 34 0 S	174 56 0 E	9	30
Campeche	Mexico	19 50 45 N	90 30 30 W		
Canary Islands, Palma, N. Point	Canaries	28 52 30 N	17 56 0 W	3	0
Candia	Candia	35 18 45 N	25 18 15 E		
Candinose Cape	White Sea	68 42 0 N	44 35 0 E		
Candlemas' Isles	Sandwich Land	57 6 0 S	27 13 0 W		
Cansaw Harbour Light	Nova Scotia	45 20 0 N	60 58 0 W		
Canso, Gut of	United States	45 44 0 N	61 31 0 W	8	30
Cantin Cape	Africa	32 33 0 N	9 15 0 W	10	0
Canton	China	23 8 9 N	113 16 54 E		
Canton Island	Chinese Sea	15 23 0 N	109 6 0 E		
Capricorn Cape	New Holland	23 28 0 S	151 15 0 E	8	0
Caraccas	Terra Firma	10 30 50 N	67 4 45 W		

TABLE XXXV.

Latitudes and Longitudes of Places, &c.

Places.	Coast, Sea, or Country.	Latitude.	Longitude.	Time H. W.
Cardigan Steeple	Wales	52° 4′ 59″N	4°38′ 18″W	7 0
Cargados-Garajos Establishment	Indian Ocean	16 25 0 S	59 41 0 E	
Cariman	Java	5 50 0 S	110 34 0 E	
Carimata Island, Peak	Indian Archipelago	1 37 0 S	108 53 0 E	
Carlscrona	Sweden	56 9 40 N	15 33 0 E	
Carmel Cape	Syria	32 51 10 N	34 57 35 E	
Carmen Island, N. Point	Gulf of Mexico	18 52 0 N	91 23 0 W	
Carnicobar Island	Bay of Bengal	9 10 0 N	92 56 0 E	
Carthagena	Spain	37 35 40 N	1 1 51 W	
Carthagena	Terra Firma	10 25 38 N	75 29 45 W	
Carboeiro Cape	Portugal	39 22 0 N	9 25 0 W	
Carysfoot Island	Pacific Ocean	20 44 53 S	138 19 28 W	
Caskett Lights	France	49 44 30 N	2 25 10 W	8 0
Cat Island, N. Point	Lucayos	24 37 0 N	75 36 0 W	
Catherine (St.) Island	Brazil	27 23 0 S	48 28 0 W	0 49
Cayenne	Guayana	4 56 0 N	52 18 0 W	3 40
Caymen (Great) Island, S. W. Pt.	Sea of Cuba	19 12 0 N	81 26 0 W	
Cefalonia Island, N. Point	Mediterranean	38 36 0 N	20 42 0 E	
Ceicer-de-Mer Island	Chinese Sea	10 32 30 N	108 53 0 E	
Ceram Island, S. W. Point	Indian Archipelago	3 31 0 S	127 56 0 E	
Cerigo Island, S. Point	Mediterranean	36 6 0 N	22 51 38 E	
Cerowa Island	Indian Archipelago	6 10 0 S	129 53 0 E	
Cette Light	France	43 23 45 N	3 42 24 E	
Ceuta Fort	Barbary	35 54 10 N	5 17 25 W	
Chain Island	Pacific Ocean	17 25 0 S	145 30 0 W	
Chaleur Bay, Entrance	United States	48 4 0 N	64 14 0 W	
Chandernagor	India	22 51 0 N	88 29 0 E	
Chansely Cape (St. Pedro)	Arabia	18 2 0 N	56 27 0 E	
Chapel Rock	Atlantic Ocean	47 28 0 N	7 30 0 W	
Charles Cape	Labrador	62 46 30 N	74 15 0 W	10 0
Charles Cape	United States	37 12 30 N	75 45 30 W	7 0
Charlton Island	Hudson's Bay	52 3 0 N	79 55 0 W	
Charleston Light	United States	32 43 30 N	79 46 0 W	7 0
Chatal Island, N. E. Point	Archipelago	37 0 7 N	27 12 30 E	
Chatham Island, C. Young	Pacific Ocean	43 48 0 S	176 58 0 W	
Chatham Island, N. E. Point	Pacific Ocean	0 45 0 S	89 9 0 W	
Cheduba Island, N. W. Point	Bay of Bengal	18 58 0 N	93 18 0 E	
Cherbourg	France	49 38 31 N	1 37 3 W	7 30
Cherry Island	Pacific Ocean	11 31 0 S	169 39 0 E	
Chin-chew Bay	China	24 45 0 N	118 40 0 E	
Christiana Island	Archipelago	36 15 0 N	25 3 45 E	
Christiana Observatory	Norway	59 54 5 N	10 44 55 E	
Christiansand	Norway	58 8 0 N	8 3 0 E	
Christmas Sound	Terra del Fuego	55 25 0 S	69 50 0 W	2 30
Christmas Island	Indian Ocean	10 34 0 S	105 33 0 E	
Christmas Island	Pacific Ocean	1 57 45 N	157 35 0 W	
Christopher's (St.) Island	Mozambique	17 2 0 S	43 9 0 E	
Christopher's (St.) Island	Carribee Isles	17 19 0 N	62 49 0 W	
Chulawan Island	E. Coast of Africa	20 38 0 S	34 48 30 E	
Churchill Cape	Hudson's Bay	58 48 0 N	93 12 0 W	7 20
Chusan Harbour, Chusan	China	30 26 0 N	121 41 0 E	
Civita Vecchia	Italy	42 5 24 N	11 44 45 E	
Clear Cape	Ireland	51 25 0 N	9 29 0 W	4 30
Clerke's Island	Sea of Kamschatka	63 15 0 N	169 40 0 W	
Clerke's Rocks	Atlantic Ocean	55 5 30 S	34 42 0 W	
Cleveland's Shoal	W. Coast of Africa	30 45 0 N	10 21 0 W	
Cloates Island	Indian Ocean	22 8 0 S	112 30 0 E	
Clyth Ness	Scotland	58 20 0 N	3 16 0 W	
Coast Castle, Cape	Africa	5 5 0 N	1 2 0 W	3 30
Coche Island, W. Point	Carribee Sea	10 47 36 N	63 51 29 W	
Cochin	India	9 57 30 N	76 29 0 E	

TABLE XXXV.

Latitudes and Longitudes of Places, &c.

Places.	Coast, Sea, or Country.	Latitude.	Longitude.	Time H. W.
Cocos Isle	Indian Ocean	3° 6′ 0″N	95°12′ 0″E	
Cocos Isles, N. Isle	Indian Ocean	11 49 45 S	97 4 0 E	
Cod Cape Light	United States	42 3 0 N	70 6 0 W	11 30
Codera Cape	Terra Firma	10 35 54 N	66 8 30 W	
Coetivy Island	Indian Ocean	7 14 0 S	56 32 0 E	
Coffin Island	Mozambique	17 30 0 S	44 4 30 E	
Colambretes Island	Mediterranean	39 56 0 N	0 40 13 E	
Colnet Cape	New Caledonia	20 30 0 S	164 56 15 E	
Colombo	Ceylon	6 57 0 N	80 0 0 E	
Columbia, R. Entrance	N. W. Coast of Amer.	46 19 0 N	123 54 0 W	
Combay Island	Indian Archipelago	7 49 0 S	123 41 0 W	
Comfort Cape	Greenland	61 55 0 N	49 26 0 W	
Comorin Cape	India	8 5 0 N	77 44 0 E	
Comoro Island	Comoro Isles	11 32 0 S	43 25 0 E	
Conception	Chili	36 49 10 S	73 4 45 W	
Condore Island, Centre	Indian Archipelago	8 40 0 N	106 42 0 E	4 16
Constantinople, (St. Sophia)	Turkey in Europe	41 0 16 N	28 55 15 E	
Copenhagen, Observatory	Denmark	55 40 53 N	12 34 46 E	
Copinsha	Orkney Islands	58 56 0 N	2 48 0 W	
Coquimbo	Chili	29 54 40 S	71 19 15 W	
Corfu Island, Town	Mediterranean	39 38 5 N	19 59 38 E	
Coringa Bay, Gordeware Point	India	16 48 0 N	82 24 0 E	8 0
Cork Cove, Quay	Ireland	51 48 10 N	8 14 30 W	6 30
Corn Island, Great	Carribean Sea	12 13 0 N	82 10 0 W	
Cornwallis Group	Pacific Ocean	44 37 0 S	175 26 0 W	
Coronation Cape	New Caledonia	22 5 0 S	167 8 0 E	
Corrientes Cape	Paraguay	38 0 0 S	57 41 0 W	
Corrientes Cape	E. Coast of Africa	24 7 30 S	35 25 0 E	
Corrientes Cape	Mexico	20 25 30 N	105 39 36 W	
Corse Cape	Corsica	43 3 0 N	9 20 0 E	
Corunna	Spain	43 23 30 N	8 18 35 W	3 0
Corvo Island, S. Point	Azores	39 40 45 N	31 2 45 W	
Cosmeledo Isles	Indian Ocean	9 45 0 S	48 40 0 E	
Cozumbe Isle, S. Point	Bay of Honduras	20 1 0 N	87 2 0 W	
Crescent Island	Pacific Ocean	23 20 29 S	134 35 0 W	
Cromer Light	England	52 55 30 N	1 36 30 E	
Cronstadt	Russia in Europe	59 59 26 N	29 49 30 E	
Crooked Island, W. End	Lucayos	22 48 0 N	74 17 15 W	
Croque Harbour	Newfoundland	51 3 0 N	55 53 0 W	6 30
Cuba, St. Jago	Cuba	19 57 20 N	76 4 30 W	
Cuddalore	India	11 43 23 N	79 48 12 E	
Culpepper's Island	Gallapagos Isles	1 40 0 N	91 55 0 W	
Cumana	Terra Firma	10 27 37 N	63 58 26 W	
Cummin Island	China	31 40 0 N	121 41 0 E	
Curaçao Island, N. Point	Carribee Sea	12 24 0 N	69 16 0 W	
Curreuse Island	Indian Ocean	4 10 0 S	55 45 0 E	5 15
Curriacou Island	Carribee Isles	12 30 0 N	61 31 0 W	
Cuxhaven Light	Germany	53 53 0 N	8 44 2 E	1 0
Danger Isles, Centre	Pacific Ocean	10 51 0 S	167 4 45 W	
Dantzic	Prussia	54 20 48 N	18 38 5 E	
Dassen Island, Centre	S. W. Coast of Africa	33 26 0 S	18 1 30 E	
Dauphin Fort	Madagascar	25 1 0 S	46 57 0 E	
David's (St.) Head	Wales	51 54 30 N	5 17 30 W	6 0
David's (St.) Isles	Pacific Ocean	0 55 0 N	134 21 0 E	
Davis's Inlet, Entrance	Labrador	55 48 0 N	60 12 0 W	
Deal Castle	England	51 13 5 N	1 23 59 E	11 15
De Bas Island	France	48 46 15 N	4 2 0 W	3 45
De Galle Point	Ceylon	6 1 0 N	80 19 20 E	
De Gratt Cape	Newfoundland	51 40 0 N	55 30 0 W	
De la Estaca Point	Spain	43 47 40 N	7 36 0 W	

TABLE XXXV.

Latitudes and Longitudes of Places, &c.

Places.	Coast, Sea, or Country.	Latitude.	Longitude.	Time H. W.
Delagoa B. Cape Colatto	E. Coast of Africa	26° 4′ 0″ S	32° 56′ 0″ E	5 15
Dela Vela Cape	Terra Firma	12 11 0 N	72 15 0 W	
Delgado Cape, Extreme	E. Coast of Africa	10 41 0 S	40 35 0 E	
Delos Islands, Factory	Senegambia	9 22 0 N	13 32 0 W	
Denbigh Cape	Behring's Straits	64 17 0 N	161 53 0 W	
Deseada Island, N. E. Point	Carribee Isles	16 20 0 N	61 50 0 W	
Desert Isles	Indian Ocean	48 5 0 S	48 0 0 E	
Desolation Cape	Greenland	60 58 0 N	49 0 0 W	
Desolation Cape	Terra del Fuego	54 55 0 S	71 42 0 W	
Despair Cape	United States	48 27 0 N	63 57 0 W	
De Tierra Island	Pacific Ocean	33 45 0 S	78 51 13 W	
Devil's Isles, Plantain Isle	Guayana	5 27 0 N	52 34 0 W	
Devil's Rocks	Atlantic Ocean	46 25 0 N	13 0 0 W	
Dezertos, S. Point	Atlantic Ocean	32 28 0 N	16 31 0 W	
Diamond Island	Bay of Bengal	15 52 0 N	94 19 0 E	
Diego Garcia Island	Indian Ocean	7 20 0 S	72 28 0 E	
Diego Ramirez Isles	Terra del Fuego	56 27 0 S	68 36 0 W	
Dieu Island, W. Point	France	46 42 26 N	2 19 50 W	3 0
Diggis Cape	Hudson's Bay	62 41 0 N	78 49 45 W	
Direction Island	Indian Archipelago	0 15 0 N	108 10 0 E	
Disappointment Cape	South Georgia	54 58 0 S	36 15 0 W	
Disappointment Island	Pacific Ocean	9 57 0 S	167 0 0 E	
Disappointment Isles	Pacific Ocean	14 7 0 S	141 22 0 W	
Disco Island, Leifle Bay	Baffin's Bay	69 10 0 N	54 40 0 W	
Discord Cape	Greenland	60 27 0 N	43 20 0 W	
Domar Island	Indian Archipelago	2 45 0 N	105 27 0 E	
Domesness Lights	Prussia	57 46 30 N	22 30 0 E	
Domingo (St.)	St. Domingo	18 29 0 N	69 59 30 W	
Dominica Island, Roseau	Carribee Isles	15 18 23 N	61 32 5 W	
Dondre Head	Ceylon	5 55 30 N	80 43 0 E	
Dondrekin Island, S. Point	Indian Archipelago	0 54 0 S	117 36 0 E	
Dover Castle, N. Turret	England	51 7 47 N	1 19 7 E	11 15
Drontheim	Norway	63 25 50 N	10 23 25 E	2 15
Dublin Observatory	Ireland	53 23 13 N	6 21 30 W	9 30
Ducies Island, N. E. End	Pacific Ocean	24 40 20 S	124 46 0 W	
Duke of York's Island	Pacific Ocean	8 41 0 S	173 24 45 W	
Dundee	Scotland	56 28 0 N	2 58 0 W	2 15
Dunkirk	France	51 2 9 N	2 22 37 E	11 45
Dunmore Head, Light	Ireland	52 6 39 N	10 31 0 W	
Dunnose	Isle of Wight	50 37 7 N	1 11 36 W	8 56
Durours Island	Louiseade Isles	1 17 0 S	143 30 0 E	
Dwalder Isle	Indian Archipelago	4 12 0 S	116 21 0 E	
Eartholms	Baltic Sea	55 19 0 N	15 15 0 E	
East Cape	Madagascar	15 14 0 S	50 26 0 E	
East Cape	New Zealand	37 44 25 S	178 58 0 E	
Easter Island, Centre	Pacific Ocean	27 9 33 S	109 25 20 W	2 0
Ebro R. Entrance	Spain	40 42 0 N	0 57 0 E	
Eddystone Island	Solomon Isles	8 18 0 S	156 30 53 E	
Eddystone Light	England	50 10 55 N	4 15 3 W	5 13
Edgecumbe Cape	N. W. Coast of Amer.	57 2 0 N	135 50 15 W	
Egg Island	Lucayos	25 31 5 N	76 52 45 W	
El Arisch Fort	Egypt	31 5 30 N	33 45 25 E	
Elba Island, Porto Ferrajo	Mediterranean	42 49 6 N	10 19 35 E	
Eleuthera Island, Powel's Point	Lucayos	24 37 0 N	76 9 0 W	
Elizabeth Cape	Sachalin	54 24 30 N	142 46 30 E	
El Mellah Cape	Barbary	31 57 5 N	25 2 0 E	
Elsineur	Denmark	56 2 17 N	12 38 2 E	
Emden	Germany	53 22 3 N	7 12 1 E	12 0

TABLE XXXV.

Latitudes and Longitudes of Places, &c.

Places.	Coast, Sea, or Country.	Latitude.	Longitude.	Time H.	Time W.
Enatum Island	New Hebrides	20°10′ 0″S	170° 4′ 0″E		
Endeavour River, Entrance	New Holland	15 25 0 S	145 11 0 E	9	30
Engano Island	Indian Ocean	5 27 0 S	102 17 0 E		
Eoaa Island	Friendly Isles	21 24 0 S	174 30 0 W		
Epiphanes (St.) Cape	Cyprus	35 6 0 N	32 16 30 E		
Erromanga Isle, Traitor's hd.	New Hebrides	18 46 30 S	169 18 36 E		
Espichel Cape	Portugal	38 24 54 N	9 13 6 W		
Espiritu Santo	Brazil	20 15 0 S	39 28 0 W		
Esquimaux Isles	Labrador	50 18 0 N	63 15 0 W		
Estaing Bay	Sachalin	49 0 0 N	142 21 0 E		
Eustatia (St.) Island, Road	Carribee Isles	17 29 0 N	63 4 45 W		
Evouts Isles	Terra del Fuego	55 32 12 S	66 40 14 W		
Exuma Island, N. W. Point	Lucayos	23 32 0 N	75 37 0 W	6	35
Eye Island	Indian Archipelago	0 24 0 N	129 53 0 E		
Fago Island	Newfoundland	50 0 0 N	53 54 0 W		
Fair Foreland	Spitzbergen	78 53 0 N	8 45 0 E		
Fair Island	Orkney Islands	59 29 0 N	1 45 0 W	4	0
Fairweather Cape	Patagonia	51 33 0 S	69 0 0 W		
Falkland Isles, Port Egmont	Atlantic Ocean	51 24 0 S	59 56 0 W		
False Cape	E. Coast of Africa	34 25 0 S	18 52 0 E		
Fano Island, W. Point	Mediterranean	39 50 20 N	19 19 50 E		
Farewell Cape	Greenland	59 45 0 N	47 50 0 W		
Farewell Cape	New Zealand	40 31 0 S	172 47 0 E		
Farillon Island	Ladrones	16 1 0 N	146 28 0 E		
Faro, N. E. End	Baltic Sea	57 56 0 N	19 29 0 E		
Fartash Cape	Arabia	15 34 0 N	51 56 0 E		
Fatsisio Island	Japan Isles	33 13 0 N	140 12 0 E		
Fayal Island, Horta	Azores	38 32 30 N	28 43 0 W	2	20
Felicuri Island	Mediterranean	38 34 5 N	14 29 30 E		
Felix Island, (St.)	Pacific Ocean	26 16 0 S	80 3 0 W		
Ferder Light	Norway	59 3 30 N	10 36 0 E		
Fernando Noronho Island Peak	Atlantic Ocean	3 52 55 S	32 14 20 W	4	0
Fernando Po Island, N.E. Point	Atlantic Ocean	3 46 0 N	8 54 15 E		
Ferro Isle, N. End	Canary Isles	27 50 30 N	17 58 0 W	3	0
Ferrol	Spain	43 29 0 N	8 13 0 W	3	0
Finisterre Cape	Spain	42 54 0 N	9 16 0 W	3	0
Fiorenza (St.)	Corsica	42 41 2 N	9 17 43 E		
Fish Bay, N. Point	W. Coast of Africa	16 30 0 S	11 41 0 E		
Flamborough Head	England	54 8 0 N	0 2 30 W	4	30
Flatholm Light	Bristol Channel	51 22 33 N	3 6 25 W	6	40
Flattery Cape	N. W. Coast of Amer.	48 23 30 N	124 22 0 W		
Florence Observatory	Italy	43 46 41 N	11 15 45 E		
Flores Island Pt. Delgada	Azores	39 34 0 N	31 8 0 W		
Flores Island, N. E. Point	Indian Archipelago	8 5 0 S	123 2 0 E		
Florida Cape	Florida	25 41 30 N	80 5 0 W	7	30
Flushing	Netherlands	51 26 42 N	3 34 57 E	1	0
Foggy Island	N. W. Coast of Amer.	56 12 0 N	157 19 30 W		
Fogo Island, Middle	Cape Verd Isles	14 56 0 N	24 20 0 W		
Foreland (N.) Light	England	51 22 30 N	1 26 50 E	11	15
Formentera, W. Point	Mediterranean	38 37 0 N	1 24 0 E		
Formigas or Ants	Azores	37 17 10 N	25 53 0 W		
Formigues Island	Mediterranean	42 21 30 N	10 6 30 E		
Formosa, R. Entrance	W. Coast of Africa	5 43 0 N	5 25 0 E		
Formosa Island, N. E. Point	Chinese Sea	25 11 0 N	121 56 0 E		
Fortaventura Island, S.W. Point	Canaries	28 4 0 N	14 29 0 W		
Foul Point	Madagascar	17 40 14 S	49 33 15 E		
Foulness	England	52 56 20 N	1 20 30 E	9	0
Foulweather Cape	N. W. Coast of Amer.	44 49 0 N	123 56 0 W		
François Cape, Town	St. Domingo	19 46 20 N	72 17 55 W		
Francis (St.) Cape	Newfoundland	47 57 0 N	52 30 0 W		

Latitudes and Longitudes of Places, &c.

Places.	Coast, Sea, or Country.	Latitude.	Longitude.	Time H. W.
Francisco (St.) Cape	Peru	0°40′ 0″N	79°53′ 0″W	
Francisco (St.) Port	New Albion	37 48 30 N	122 8 0 W	11 25
François (Old) Cape	St. Domingo	19 40 30 N	70 1 15 W	
Fredericksham	Gulf of Finland	60 30 0 N	27 25 0 E	
Frederickstadt	Norway	59 12 0 N	11 1 0 E	
Freels Cape	Newfoundland	49 34 0 N	53 0 0 W	
Frehel Cape, Light	France	48 41 10 N	2 18 36 W	6 0
Frejus	France	43 25 52 N	6 44 9 E	
Frio Cape	Brazil	23 1 18 S	42 3 0 W	
Funon Odensee	Baltic Sea	55 24 0 N	10 22 0 E	
Furneaux Island	Pacific Ocean	17 11 0 S	143 6 40 W	
Furneaux Isles, Southern	Coast of New Holland	40 34 0 S	148 10 0 E	
Gabey Island	Indian Archipelago	0 6 0 S	126 24 0 E	
Gael Hawkes Bay	Greenland	75 0 0 N	6 51 0 W	
Galega Shoal	Indian Ocean	10 25 0 S	56 38 0 E	
Galina Point	Jamaica	18 29 30 N	76 54 0 W	
Galita Island, Centre	Mediterranean	37 32 30 N	8 55 0 E	
Galleta Island	Coast of Egypt	31 6 0 N	27 20 0 E	
Gambia, River	Africa	13 28 0 N	16 35 0 W	
Gambier Island	Pacific Ocean	23 18 23 S	134 54 0 W	
Gardafui Cape, Extreme	E. Coast of Africa	11 41 0 N	51 12 0 E	
Gaspar Island	Indian Archipelago	2 25 30 S	107 6 0 E	
Gaspee Bay	Canada	48 47 30 N	64 27 15 W	1 30
Gasses Island, S. Point	Indian Archipelago	1 41 0 S	128 20 0 E	
Gebel Tor Island	Red Sea	15 32 0 N	42 0 0 E	
Genoa Light	Italy	44 24 0 N	8 54 0 E	
George Cape	South Georgia	54 17 0 S	36 32 30 W	
George (St.) Cape	New Ireland	4 51 17 S	152 48 55 E	
George (St.) Island, S. E. Point	Azores	38 29 25 N	27 51 0 W	
George Town, Light	United States	38 55 0 N	77 6 0 W	6 40
George Town	St. John's Isle	46 14 0 N	62 20 0 W	
Georgia (S.) Island, C. Disapp.	Atlantic Ocean	54 58 0 S	36 15 0 W	
Georgia (S.) Island, N. Cape	Atlantic Ocean	54 4 45 S	38 15 0 W	
Gibraltar, Europa Point	Spain	36 6 40 N	5 21 45 W	12 0
Gillolo Island, Osser	Indian Archipelago	0 45 0 N	128 22 0 E	
Glenan Isles	W. Coast of France	47 44 30 N	4 0 20 W	
Gloucester Cape, Top	Terra del Fuego	54 30 0 S	73 1 30 W	
Gloucester Island, N. E. Point	Pacific Ocean	19 7 40 S	140 38 0 W	
Glover's Reef, N. Point	Bay of Honduras	16 49 0 N	87 36 0 W	
Goa, Algoada Point	India	15 29 30 N	73 53 30 E	4 30
Goat Island	Philippine Isles	13 52 0 N	120 6 0 E	
Godthaab	Greenland	64 10 0 N	51 48 0 W	
Gomera Island, Port	Canaries	28 5 40 N	17 7 0 W	
Good Hope Cape, Extreme Point	New Guinea	0 20 0 S	132 31 0 E	
Good Hope Cape, Flagstaff	S. Coast of Africa	34 22 40 S	18 24 15 E	3 0
——— Town	S. Coast of Africa	33 55 15 S	18 20 30 E	2 30
Goonong Apee Island, Peak	Indian Archipelago	8 11 0 S	119 5 0 E	
Gordewar Point	India	16 48 0 N	82 24 0 E	
Goram Island	Indian Archipelago	4 0 0 S	131 34 0 E	
Gore Island	Sea of Kamschatka	60 17 0 N	172 30 45 W	
Goree Island, Gov. House	W. Coast of Africa	14 39 34 N	17 25 0 W	1 30
Gorgona Island	Mediterranean	43 25 46 N	9 53 10 E	
Gorgona Island	Pacific Ocean	2 53 0 N	78 6 15 W	
Gottenburg	Sweden	57 41 18 N	11 54 33 E	
Gottland, N. E. End	Baltic Sea	57 51 0 N	19 7 0 E	
Gough's Island	Atlantic Ocean	40 18 0 S	9 42 0 W	
Gough's Rocks	Atlantic Ocean	40 25 0 N	33 0 0 W	
Gower Cape	China	36 57 0 N	122 19 0 E	
Goza, S. Point	Mediterranean	34 35 0 N	24 20 0 E	
Gracias-a-Dios Cape	Mexico	14 56 30 N	82 45 0 W	

TABLE XXXV.

Latitudes and Longitudes of Places, &c.

Places.	Coast, Sea, or Country.	Latitude.	Longitude.	Time H. W.
Graciosa Island, Santa Cruz	Azores	39° 5′ 0″N	28° 0′ 0″W	
Grampus Isles	Pacific Ocean	25 10 0 N	146 0 0 E	
Greenwich Observatory	England	51 28 39 N	0 0 0	2 28
Grenada Island, Fort Royal	Carribee Isles	12 2 54 N	61 48 0 W	
Grenville's Inlet	E. Florida	26 47 0 N	80 1 0 W	
Grim Cape	Van Dieman's Land	40 41 0 S	144 46 0 E	
Groais Island, N. End	Newfoundland	51 0 0 N	55 42 0 W	
Groote Island, Central Hill	New Holland	13 57 0 S	136 41 0 E	
Guadalcanal Island, C. Esper	Solomon Isles	9 31 33 S	159 41 30 E	
Guadaloupe Island	Pacific Ocean	28 53 0 N	118 15 48 W	
Guadaloupe Island, Basseterre	Carribee Sea	15 59 30 N	61 48 15 W	
Guam Island, Umatai B. Castle	Pacific Ocean	13 28 18 N	144 46 45 E	
Guascama Point	Terra Firma	2 29 0 N	78 22 45 W	
Guayaquil	Peru	2 11 30 S	79 41 15 W	7 0
Guernsey Island, St. Pierre	British Channel	49 25 33 N	2 33 0 W	6 0
Hackluyt's Head	Spitzbergen	79 46 0 N	9 49 0 E	1 30
Hague	Netherlands	52 4 50 N	4 18 47 E	8 15
Hailin Island, W. Point	China	21 34 30 N	111 54 15 E	
Halifax	Nova Scotia	44 40 0 N	63 38 8 W	7 30
Hamburgh Observatory	Germany	53 32 51 N	9 58 37 E	6 0
Hammerfest	Norway	70 38 22 N	23 43 30 E	
Hammond's Rock	Atlantic Ocean	36 45 0 N	23 10 0 W	
Hangcliff	Shetland Isles	60 9 0 N	0 56 30 W	9 30
Hano Island	Sweden	56 1 0 N	14 49 30 E	
Hanover (New) Island S. W. Pt.	Pacific Ocean	2 31 0 S	149 50 0 E	
Hapae, N. Point	Friendly Isles	19 48 0 S	174 5 0 W	
Harbour Island, N. Point	Lucayos	25 30 0 N	76 37 0 W	
Harlem	Netherlands	52 22 56 N	4 38 19 E	9 0
Harlem's Bay, Mondoza Island	China	22 31 22 N	114 50 45 E	
Harvey's Island	Pacific Ocean	19 17 0 S	158 56 20 W	
Haselo Island	Cattegat	56 11 46 N	11 39 46 E	
Hastings' Island	Indian Archipelago	6 39 0 S	116 26 0 E	
Hatteras Cape	United States	35 14 30 N	75 34 27 W	9 0
Havanah, Moro	Cuba	23 9 27 N	82 22 53 W	
Havre de Grace	France	49 29 14 N	0 6 38 E	10 30
Haweis Island	Carolines	7 30 0 N	146 28 0 E	
Heckla Cape	Iceland	63 22 0 N	19 54 0 W	
Hegadis Island	Indian Archipelago	6 13 0 S	122 40 0 E	
Helena (St.) Island, James Town	Atlantic Ocean	15 55 0 S	5 44 48 W	2 15
Helen's Shoal	Pacific Ocean	2 51 0 N	131 34 0 E	
Heligoland Island Light	German Ocean	54 11 34 N	7 53 13 E	11 0
Helvoetsluys	Netherlands	51 49 29 N	3 27 53 E	1 30
Henry and Kenery Isles	Indian Ocean	18 42 20 N	72 53 0 E	
Henrietta Cape	Hudson's Bay	55 10 0 N	82 30 0 W	
Henlopen	United States	38 47 0 N	75 6 30 W	9 0
Henry Cape Light	United States	36 57 0 N	75 47 0 W	7 0
Hermogenes (St.) Island	N. W. Coast of Amer.	58 10 30 N	151 30 0 W	
Hesseloe Island	Denmark	56 11 46 N	11 42 0 E	
Hinchinbrook Cape	N. W. Coast of Amer.	60 12 30 N	146 39 20 W	
Hogland Island Light	Gulf of Finland	60 3 0 N	27 7 0 E	
Hogsties Isles, E. Isle	Lucayos	21 38 50 N	73 56 4 W	
Hola	Iceland	65 44 0 N	19 43 45 W	
Holy Island, Castle	England	55 40 20 N	1 46 38 W	2 30
Holyhead Mount, Sig. Staff	England	53 18 51 N	4 39 27 W	10 10
Honfleur Light	France	49 25 13 N	0 14 14 E	9 0
Hood's (Lord) Island	Pacific Ocean	21 42 0 S	135 32 0 W	
Hope Island	Spitzbergen	76 30 0 N	20 28 0 E	
Horn Cape	Terra del Fuego	55 58 30 S	67 11 14 W	
Howe's (Lord) Island	Pacific Ocean	31 30 0 S	159 0 0 E	
Huahine Island, Owharree Bay	Pacific Ocean	16 42 46 S	151 9 6 W	11 50

Latitudes and Longitudes of Places, &c.

Places.	Coast, Sea, or Country.	Latitude.	Longitude.	Time H. W.
Hunter's Islands	Van Dieman's Land	40°24′ 0″S	144°41′ 0″E	
Hurst Lights	England	50 42 23 N	1 32 46 W	10 0
Husum	Denmark	54 28 48 N	9 3 42 E	
Icy Cape	N. W. Coast of Amer.	70 29 0 N	161 42 30 W	
Ildefonzo (St.) Isle	Terra del Fuego	55 55 0 S	69 18 0 W	
Inague (Great) Island, W. End	Lucayos	21 3 40 N	73 47 20 W	
Inverness	Scotland	57 31 0 N	4 11 30 W	11 50
Isle of Pines	New Caledonia	22 42 0 S	167 34 0 E	
Ives (St.)	England	50 13 0 N	5 28 0 W	4 30
Ivica Island, Castle	Mediterranean	38 53 16 N	1 29 12 E	
Jackson (Port) Castle Point	New Holland	33 51 30 S	151 16 30 E	8 15
Jaffa	Syria	32 3 25 N	34 44 18 E	
Jago (St.) Island, Porto Praya	Cape Verd Isles	14 53 50 N	23 31 20 W	11 0
Jarra Island	Straits of Malacca	4 0 0 N	100 14 0 E	
Java Head	Java	6 48 0 S	105 11 0 E	
Jean de Luz (St.)	France	43 23 15 N	1 40 32 W	
Jedo (Niphon Island)	Japan Isles	36 29 0 N	140 0 0 E	
Jersey Island, St. Aubin	British Channel	49 12 59 N	2 10 44 W	6 0
Jervis Island	Torres Strait	9 56 30 S	142 9 0 E	
Jesso Island, Cape Euroen	Japan Sea	42 2 0 N	143 18 0 E	
Jesus Island	Friendly Isles	6 46 0 S	166 0 0 W	
Johanna Island, Centre	Comoro Isles	12 16 0 S	44 30 0 E	
John's (St.) River, Entrance	Canada	50 20 0 N	63 57 0 W	
John's (St.) Fort	Newfoundland	47 33 45 N	52 39 45 W	6 0
John's (St.) Island, East Cape	Carribee Isles	18 20 30 N	64 47 9 W	
John de Nova Isles	Indian Ocean	10 15 0 S	52 20 0 E	
Johnston's Isles	Pacific Ocean	16 53 20 N	169 31 30 W	
Jones's Cape	Hudson's Bay	54 50 0 N	78 54 0 W	
Joseph (St.)	California	23 3 13 N	109 40 53 W	
Josna Rock	Atlantic Ocean	31 37 0 N	23 45 0 W	
Juan (St.) Cape	Staten Land	54 47 0 S	63 42 0 W	4 0
Juan Baptista (St.)	Pacific Ocean	25 57 0 S	137 56 0 W	
Juan de Nova, Centre	Mozambique	17 3 30 S	42 42 20 E	
Juan Fernandez Island	Pacific Ocean	33 40 0 S	78 58 15 W	
Julian (St.) Port	Patagonia	49 16 0 S	67 38 5 W	4 45
Kalatoa Island	Indian Archipelago	7 20 0 S	121 40 0 E	
Kamschatkoi Ness	Kamschatka	56 1 0 N	163 22 30 E	
Karack Island, Flagstaff	Gulf of Persia	29 15 45 N	50 27 0 E	
Kent's Group	New Holland	39 27 0 N	147 15 0 E	
Keppel Bay	New South Wales	23 29 30 S	150 58 0 E	
Keppel's Island	Friendly Isles	15 53 0 S	174 12 0 W	
Kerguelan's Land, Christ. Harb.	Indian Ocean	48 41 15 S	69 2 15 E	10 0
King's Island, North Point	Bass's Straits	39 37 0 S	143 54 10 E	3 30
King George's Sound	New Holland	35 6 0 S	118 1 0 E	
Kingston	Jamaica	17 50 30 N	76 42 0 W	
Kilda (St.)	Lewis Islands	57 49 0 N	8 26 0 W	
Kinnaird's Head	Scotland	57 42 0 N	2 1 0 W	12 0
Kinsale, Light	Ireland	51 36 20 N	8 33 20 W	4 30
Kioge	Denmark	55 26 40 N	12 12 0 E	
Koskar Light	Gulf of Finland	59 40 30 N	25 3 0 E	
Kola	Russia in Europe	68 52 30 N	33 0 45 E	
Koll Light	Sweden	56 18 3 N	12 27 45 E	
Konigsberg	Baltic	54 42 50 N	20 10 6 E	
Korsar Light	Denmark	55 20 22 N	11 8 30 E	
Kuisin, South End	Japan Isles	31 48 0 N	132 35 0 E	
Kurile Isles, North End	Pacific Ocean	47 10 0 N	153 6 0 E	
Laccadive Isles, N. W. Point	Indian Ocean	13 30 0 N	70 45 0 E	

TABLE XXXV.

Latitudes and Longitudes of Places, &c.

Places.	Coast, Sea, or Country.	Latitude.	Longitude.	Time H. w.
Ladrone Island (Great)	Chinese Sea	21°57′ 0″N	113°43′ 0″E	
Lagoon Island	Pacific Ocean	18 48 0 S	138 38 0 W	
Lambaness	Shetland Isles	60 48 40 N	0 58 30 W	9 30
Landscroon	Sweden	55 52 27 N	12 50 1 E	
Land's End	England	50 4 7 N	5 41 31 W	4 30
Landsorbe Light	Sweden	58 43 56 N	17 52 0 E	
Langle Bay	Sachalin	47 48 36 N	142 17 54 E	
Lati Island	Friendly Isles	18 54 0 S	174 48 0 W	
Lawrence (St.) Isle	Sea of Kamschatka	63 47 0 N	171 45 0 E	
Lawrence (St.) Isle	Indian Ocean	9 35 0 S	52 15 0 E	
Ledo Cape, N. Extreme	Africa	9 46 0 S	13 12 0 E	
Leghorn	Italy	43 33 5 N	10 16 45 E	
Lekeyo, North End	Chinese Sea	27 52 0 N	128 45 0 E	
Le Memes Reef	Indian Ocean	1 20 0 N	94 20 0 E	
Lemma Island (Great) Centre	Chinese Sea	22 2 30 N	114 16 0 E	
Lemnos Island	Archipelago	39 54 0 N	24 53 0 E	
Lepanto	Turkey in Europe	38 16 0 N	22 1 0 E	
Lessoe Island, East End	Cattegat	57 19 0 N	11 10 30 E	
Lew Chew Island (Great)	Chinese Sea	26 14 0 N	127 38 0 E	
Libau	Courland	56 31 36 N	20 55 20 E	
Lima	Peru	12 2 30 S	77 7 45 W	
Limerick	Ireland	52 42 0 N	8 41 0 W	
Lincoln Island	Chinese Sea	16 41 0 N	112 42 0 E	
Lindesnes Light	Norway	57 57 50 N	7 3 15 E	
Lingin Island, South E. Point	Indian Archipelago	0 21 0 S	105 4 0 E	
Lion's Bank	Atlantic Ocean	56 40 0 N	17 45 0 W	
Lipari Island, Castle	Mediterranean	38 28 35 N	14 55 40 E	
Lisbon Observatory	Portugal	38 42 24 N	9 8 30 W	2 15
Lisburne Cape	N. W. Coast of Amer.	69 5 0 N	165 22 30 W	
Lissa Island, South Point	Gulf of Venice	43 3 0 N	16 25 0 E	
Lissamatula Island, S. E. Point	Indian Archipelago	1 46 0 S	126 32 0 E	
Liverpool (St. Paul's)	England	53 24 40 N	2 58 55 W	11 8
Lizard W. Light	England	49 57 44 N	5 11 12 W	7 50
Loango River, Entrance	W. Coast of Africa	4 39 30 S	11 42 0 E	
Lomblen Island, H. Peak	Indian Archipelago	8 12 0 S	123 52 0 E	
Lombock Island, Peak	Indian Archipelago	8 21 30 S	116 26 0 E	
London (New) Light	United States	41 21 8 N	72 9 30 W	
London, St. James's Ch., Piccadilly	England	51 30 31 N	0 8 5 W	2 45
———, St. Paul's	England	51 30 49 N	0 5 47 W	
Long Island, E. Point Light	United States	41 4 30 N	71 51 50 W	3 0
Long Island, S. E. Point	Lucayos	22 52 0 N	74 50 0 W	
Lopatka Cape	Kamschatka	51 0 15 N	156 42 45 E	
Lorenzo, (St.) Cape	Peru	1 4 0 S	80 43 0 W	
L'Orient	France	47 45 11 N	3 21 2 W	
Louisburg	Cape Breton Isle	45 53 40 N	59 54 45 W	7 15
Loyalty Isles	New Caledonia	20 54 0 S	166 30 0 E	
Lubeck Island	Indian Archipelago	5 45 0 S	112 48 0 E	
Lucas (St.) Cape	California	22 44 0 N	109 54 0 W	
Lucia Island (St.) Careenage	Carribee Isles	13 57 0 N	61 7 0 W	
Lucipara Island	Indian Archipelago	3 13 30 S	106 10 0 E	
Macao	China	22 11 30 N	113 31 30 E	9 52
Macassar	Celebes	5 9 0 S	119 39 0 E	
Macauley Island, W. Point	Pacific Ocean	30 17 50 S	176 46 50 W	
Macclesfield Bank, N. E. Side	Chinese Sea	16 2 0 N	114 42 0 E	
Macri Cape	Turkey in Europe	40 30 0 N	25 38 0 E	
Madeira Island, Funchal	Atlantic Ocean	32 37 0 N	16 55 30 W	0 4
Madeira Island, East Point	Indian Archipelago	6 53 0 S	113 58 30 E	
Madras, Flagstaff	India	13 4 0 N	80 22 0 E	
Magadoxa	E. Coast of Africa	2 5 0 N	45 49 0 E	
Magdalen Isles, S. End	Gulf of St. Lawrence	47 11 0 N	61 43 0 W	

Latitudes and Longitudes of Places, &c.

Places.	Coast, Sea, or Country.	Latitude.	Longitude.	Time H. W.
Mahe Isles, St. Anne's Island	Indian Ocean	4°35′ 0″S	55°35′ 0″E	
Mahon, Cape Mola	Minorca	39 51 10 N	4 18 17 E	
Mahouna Island	Pacific Ocean	14 21 0 S	170 16 35 W	
Maize Cape	Cuba	20 16 40 N	74 10 15 W	
Malacca Fort	India	2 12 0 N	102 15 0 E	10 30
Malaga Cathedral	Spain	36 42 18 N	4 28 2 W	
Maldives Isles, N. W. Point	Indian Ocean	7 6 0 N	73 8 0 E	
Maldives Isles, S. E. Point	Indian Ocean	0 36 0 S	73 25 0 E	
Malespina Cape	Jesso	43 42 15 N	141 19 0 E	
Mallicolo Island, Port Sandwich	New Hebrides	16 25 20 S	167 53 0 E	
Malta Island, Valetta Obs.	Mediterranean	35 53 0 N	14 30 35 E	
Mancap Island	Indian Archipelago	3 1 0 S	110 7 0 E	
Mandarine's Cap Island	Chinese Sea	21 28 0 N	112 21 30 E	
Manilla	Philippine Isles	14 36 8 N	120 58 0 E	
Mansfelt Island, N. End	Hudson's Bay	62 38 30 N	80 33 0 W	
Maouna Island, Massacre Cove	Friendly Isles	14 20 45 S	170 16 50 W	
Marabia Reef, W. Point	Red Sea	19 11 0 N	40 5 0 E	
Maracaybo	Terra Firma	10 39 0 N	71 44 0 W	
Maragalong Isles	Indian Archipelago	3 41 0 S	116 54 0 E	
Marble Island	Hudson's Bay	62 33 0 N	91 6 0 W	
Margarita Island, Cape Isla	Carribee Sea	11 10 0 N	63 58 12 W	
Mariere Island	Pacific Ocean	4 19 30 N	132 28 0 E	
Marigalante Island, S. Point	Carribee Isles	15 51 0 N	61 19 0 W	
Mariguana Island, S. W. Point	Lucayos	22 22 30 N	73 10 0 W	
Marikan Island, N. End	Kurile Isles	47 10 0 N	153 6 15 E	
Maritimo Island, Castle	Mediterranean	38 3 29 N	12 12 0 E	
Marseilles Observatory	France	43 17 49 N	5 22 15 E	
Marstrand Island, Light	Sweden	57 53 11 N	11 35 0 E	
Martha (St.)	Terra Firma	11 19 34 N	74 8 30 W	
Martin (St.) Island, N. W. Point	Carribee Isles	18 4 26 N	63 14 27 W	
Martinico Island, Fort Royal	Carribee Isles	14 35 49 N	61 5 45 W	
Martin Vas Rocks	Atlantic Ocean	20 29 30 S	28 54 20 W	3 45
Mary (St.) Cape	Italy	39 47 30 N	18 23 20 E	
Mary (St.) Island, Town	Azores	36 57 40 N	25 12 20 W	
Masafuera Island	Pacific Ocean	33 45 30 S	80 42 0 W	
Masulipatam	India	16 11 0 N	81 12 45 E	
Matapan Cape	Turkey in Europe	36 22 58 N	22 29 30 E	
Matelota Isles, Largest	Pacific Ocean	8 17 0 N	137 34 0 E	
Matthew's (St.) Island	Atlantic Ocean	1 55 0 S	9 25 0 W	
Mauritius Island, Port Lewis	Indian Ocean	20 9 45 S	57 28 30 E	12 0
May Cape	United States	38 56 46 N	74 53 6 W	8 45
May Island, Light	Scotland	56 11 22 N	2 32 47 W	1 30
Mayen's (John) Island	Greenland	71 8 20 N	7 26 0 W	
Mayo Island, S. Point	Cape Verd Isles	15 6 42 N	23 9 10 W	
Memel	Russia in Europe	55 42 15 N	21 8 3 E	
Mendocino Cape	N. W. Coast of Amer.	40 29 0 N	124 29 15 W	
Meroe Island	Bay of Bengal	7 29 0 N	93 46 0 E	
Messina Light	Sicily	38 11 30 N	15 35 30 E	
Mexico	Mexico	19 25 45 N	99 5 15 W	
Miatea Island	Pacific Ocean	17 52 20 S	148 6 0 W	
Michael's (St.) Island, E. Point	Azores	37 48 15 N	25 10 15 W	
Middle Island, S. W. Point	Chinese Sea	2 55 0 S	107 3 45 E	
Middleton's Shoals	Pacific Ocean	29 18 0 S	159 28 0 E	
Milo Island, Port	Archipelago	36 42 30 N	24 13 32 E	
Mindanao	Philippine Isles	7 10 0 N	124 30 0 E	
Mindora Island, Calavite Point	Philippine Isles	13 27 0 N	120 20 0 E	
Mobile Point	Florida	30 10 0 N	88 0 0 W	
Mocha	Arabia	13 20 0 N	43 20 0 E	
Mohilla Island, E. Point	Mozambique Channel	12 20 0 S	43 55 30 E	
Mombas Harbour, Entrance	East Coast of Africa	4 4 0 S	39 38 0 E	0 0
Montego Bay	Jamaica	18 30 0 N	77 54 0 W	

TABLE XXXV.

Latitudes and Longitudes of Places, &c.

Places.	Coast, Sea, or Country.	Latitude.	Longitude.	Time H. W.
Montery	New Albion	36°35′ 45″N	121°51′ 6″W	7 30
Montpelier Observatory	France	43 36 16 N	3 52 40 E	
Morotoi Island	Sandwich Isles	21 10 0 N	157 16 45 W	
Morshom Island, S. Point	White Sea	66 40 0 N	43 27 0 E	
Mossell Bay, Cape St. Blaize	South Coast of Africa	34 7 0 S	22 6 36 E	3 15
Mozambique Harbour Island	East Coast of Africa	15 1 30 S	40 43 0 E	4 15
Mugares Island, Centre	Gulf of Mexico	21 15 0 N	86 39 0 W	
Mulgrave Cape	Behring's Straits	67 45 30 N	165 12 0 W	
Mull of Cantire Light	Scotland	55 18 30 N	5 48 47 W	9 0
Mull of Galloway Light	Scotland	54 38 20 N	4 51 6 W	11 15
Mytelene Island, Sigri	Archipelago	39 13 0 N	25 41 0 E	
Nabon Cape	Persia	27 24 0 N	52 52 0 E	
Nagel Island	N. Coast of Lapland	68 25 0 N	37 35 0 E	
Nangasaki	Japan	32 43 40 N	129 52 7 E	7 53
Nankin	China	32 4 40 N	118 47 15 E	
Nantes Cathedral	France	47 13 8 N	1 32 54 W	4 0
Nantucket Light	United States	41 23 0 N	70 1 0 W	0 3
Naples Observatory	Italy	40 51 55 N	14 15 55 E	9 30
Narcondam Island	Bay of Bengal	13 24 0 N	94 12 0 E	
Natunas (Great) S. End	Chinese Sea	3 40 0 N	108 19 0 E	
Navigator's Island, E. Point	Friendly Isles	14 9 10 S	169 1 50 W	
Naze or Lindeness	Norway	57 57 50 N	7 3 15 E	11 15
Necker Island	Sandwich Isles	23 34 0 N	164 31 45 W	
Negril North	Jamaica	18 24 0 N	78 30 0 W	
Negro Cape Pillar	West Coast of Africa	15 40 40 S	11 53 20 E	
Negro Cape Island	United States	43 33 0 N	65 17 50 W	
Nevis Island, S. Point	Carribee Isles	17 5 12 N	62 33 21 W	
Nice	Italy	43 41 53 N	7 16 57 E	
Nicholas (St.) Mole	St. Domingo	19 49 20 N	73 29 33 W	
Nicholas (St.) N. Point	Cape Verd Isles	16 42 0 N	24 20 36 W	
Nicobar Island (Great) S. Point	Bay of Bengal	6 45 0 N	94 0 0 E	
Nieuport	Netherlands	51 7 42 N	2 45 15 E	11 45
Ningpo	China	29 57 45 N	120 18 15 E	
Niphon Island, S. W. End	Japan Isles	34 24 0 N	132 10 0 E	
Noir Cape	Terra del Fuego	54 51 30 S	73 16 14 W	
Nootka Sound	N. W. Coast of Amer.	49 35 0 N	126 37 0 W	0 20
Norfolk Island	Pacific Ocean	29 1 45 S	168 10 15 E	1 0
North Cape	South Georgia	54 4 45 S	38 15 0 W	
North Cape	Lapland	71 10 0 N	25 50 45 E	3 0
North West Cape	New Holland	21 50 30 S	114 28 0 E	
Noss Head	Scotland	58 30 0 N	3 9 0 W	9 15
Odessa Cathedral	Black Sea	46 28 55 N	30 44 14 E	
Oheteroa Island	Pacific Ocean	22 26 36 S	150 48 45 W	
Ohitahoo Island, Resolution Bay	Marquesas	9 55 30 S	139 8 25 W	2 30
Okhotsk	Russia in Asia	59 20 10 N	143 12 30 E	
Oland Island, S. Cape Light	Sweden	56 12 40 N	16 24 30 E	
Oleron, Tower	France	46 3 0 N	1 25 0 W	3 0
Olonne Shoals	West Coast of France	46 29 52 N	1 46 50 W	3 30
Ombay Island, N. W. End	Indian Archipelago	8 9 0 S	124 27 0 E	
Oneeheou Island	Sandwich Isles	21 45 0 N	160 10 0 W	
Onega	White Sea	63 54 0 N	37 58 0 E	
Opara Island	Pacific Ocean	27 36 0 S	144 11 0 W	
Oporto Bar	Portugal	41 8 54 N	8 37 18 W	3 15
Orford Cape	N. W. Coast of Amer.	42 51 0 N	124 25 0 W	
Orfordness Light	England	52 5 0 N	1 34 14 E	11 0
Orleans (New)	United States	29 57 45 N	90 11 0 W	
Ormus Island, N. End	Gulf of Persia	27 7 0 N	56 37 0 E	
Ortegal Cape	Spain	43 46 40 N	7 56 7 W	3 0

Latitudes and Longitudes of Places, &c.

Places	Coast, Sea, or Country.	Latitude.	Longitude.	Time H. W.
Orua Island, S. E. Point	Carribee Isles	12 25 0 N	69 59 0 W	
Ostend	Netherlands	51°13′ 57″N	2°55′ 8″E	0 20
Otaheite Island, Venus Point	Pacific Ocean	17 29 15 S	149 35 45 W	10 38
Owhyee Island, N. Point	Sandwich Isles	20 17 0 N	155 58 45 W	
Owhyee Island, S. Point	Sandwich Isles	18 54 30 N	155 45 0 W	
Padang Head	Sumatra	0 56 0 S	99 58 0 E	
Padaran Cape, Congo River	West Coast of Africa.	6 14 0 S	12 40 0 E	
Palawan Island, Long Point	Philippine Isles	9 38 30 N	118 22 0 E	
Palermo Observatory	Sicily	38 6 44 N	13 22 0 E	
Palliser Cape	New Zealand	41 24 0 S	175 41 0 E	
Palliser's Island	Pacific Ocean	15 38 0 S	146 29 0 W	
Palma Island, N. Point	Canaries	28 52 30 N	17 56 30 W	
Palma Town	Majorca	39 34 4 N	2 39 15 E	
Palmerston's Island	Pacific Ocean	18 0 30 S	163 12 0 W	
Palmiras Point	India	20 44 0 N	87 6 0 E	8 30
Panama	Terra Firma	8 58 50 N	79 21 15 W	3 0
Panay Island, Pt. Nasog	Philippine Isles	10 25 0 N	122 6 0 E	
Pangootaran Island	Indian Archipelago	6 15 0 N	120 40 0 E	
Para River, Entrance	Brazil	1 28 0 S	49 30 30 W	
Paris, Royal Observatory	France	48 50 13 N	2 20 24 E	
Paros Island, Mount St. Elias	Archipelago	37 2 46 N	25 11 25 E	
Parshongshan, S. W. End	Chinese Sea	23 41 0 N	124 9 0 E	
Passaro Cape	Sicily	36 41 45 N	15 8 50 E	
Passoo Keah Island	Paracels	16 6 0 N	111 46 0 E	
Pat-chow Isles, E. Isle	Pacific Ocean	24 42 0 N	125 36 0 E	
Paul's (St.) Cape	West Coast of Africa.	5 44 0 N	1 7 0 E	
Paul's (St.) Island or Rock	Atlantic Ocean	0 55 0 N	29 30 0 W	
Paul's (St.) Island	Indian Ocean	38 42 0 S	77 18 0 E	
Paul de Leon (St.)	France	48 41 24 N	4 0 0 W	5 15
Pedro Shoals, El Cascabel	Carribee Sea	17 24 0 N	78 56 0 W	
Pelagosa Island	Gulf of Venice	42 29 0 N	16 24 0 E	
Pelew Isles, S. Point, Angoura I.	Pacific Ocean	6 53 30 N	134 21 0 E	
Pembroke Cape	Hudson's Straits	62 57 9 N	82 36 0 W	12 0
Penobscot	United States	44 24 0 N	68 45 0 W	10 45
Penrhyns Island	Pacific Ocean	9 12 0 S	157 43 0 W	
Pentland Skerries	Orkney Isles	58 41 38 N	2 55 0 W	10 30
Pera Island	Straits of Malacca	5 42 0 N	99 1 0 E	
Pernambuco, Fort Picao	Brazil	8 3 27 S	34 52 0 W	
Peros Banhos Isles. Centre	Indian Ocean	5 23 0 S	71 57 0 E	
Petersburg	Russia in Europe	59 56 23 N	30 18 45 E	
Peter's (St.) Island	Indian Ocean	9 22 0 S	51 45 0 E	
Peter's (St.) Island, Town	Newfoundland	46 46 30 N	56 10 0 W	
Petropaulowski Ostrog	Kamschatka	53 0 15 N	158 49 0 E	4 36
Peyster's Isles, S. Point	Pacific Ocean	8 5 0 S	178 17 0 E	
Philadelphia	United States	39 57 2 N	75 9 30 W	2 0
Philip Isles	Pacific Ocean	8 6 0 N	140 3 0 E	
Pickersgill's Harbour	New Zealand	45 47 27 S	166 18 9 E	10 57
Pickersgill Isle	South Georgia	54 42 30 S	36 58 0 W	
Pico Island, Peak	Azores	38 26 12 N	28 28 12 W	
Pigeon Island	India	14 3 30 N	74 32 0 E	
Pilcir Island	France	47 2 32 N	2 21 5 W	3 0
Pine's Island	New Caledonia	22 42 0 S	167 34 0 E	
Piscadore Isles, Largest	Chinese Sea	25 32 0 N	119 46 0 E	
Pitcairn's Island	Pacific Ocean	25 4 0 S	130 25 0 W	
Plymouth, New Church	England	50 22 20 N	4 7 16 W	5 30
Pomona Isle, Stromness	Orkney Islands	58 57 0 N	3 28 30 W	3 0
Pondicherry	India	11 56 0 N	79 52 0 E	
Pondy Island	Indian Archipelago	7 0 0 S	113 40 0 E	
Popo Island, S. E. Point	Indian Archipelago	1 12 0 S	129 52 0 E	
Port-au-Prince	St. Domingo	18 33 42 N	72 27 11 W	

TABLE XXXV.

Latitudes and Longitudes of Places, &c.

Places.	Coast, Sea, or Country.	Latitude.	Longitude.	Time H. W.
Portland Island	Iceland	63° 22′ 0″N	18° 53′ 45″W	
Portland Isles	Pacific Ocean	2 36 0 S	149 39 0 E	
Portland Light	England	50 31 22 N	2 26 50 W	7 15
Port Jackson	Nova Scotia	44 10 0 N	64 28 0 W	8 0
Port Lewis	France	47 42 47 N	3 21 14 W	4 30
Port Mahon	Minorca	39 51 48 N	4 18 30 E	
Port Patrick Light	Scotland	54 50 22 N	5 8 0 W	
Port Royal	Jamaica	18 0 0 N	76 45 6 W	
Port St. Juan	Vancouver's Isle	48 34 0 N	124 8 0 W	
Porto Bello	Terra Firma	9 33 9 N	79 35 0 W	
Porto Rico, Point Bruguin	Porto Rico	18 29 10 N	66 13 15 W	
Porto Santo Island, Town	Atlantic Ocean	33 3 15 N	16 17 15 W	
Portsmouth Observatory	England	50 48 3 N	1 5 59 W	11 36
Portuguese Shoals	Indian Ocean	12 30 0 S	46 47 0 E	
Praslin Island	Indian Ocean	4 19 0 S	55 47 0 E	
Pratas Island	Chinese Sea	20 47 0 N	116 38 0 E	
Preparis Island, Centre	Bay of Bengal	14 52 0 N	93 41 0 E	
Prince's Island, Peaked Hill	Straits of Sunda	6 35 0 S	105 15 0 E	
Prince's Island, Port St. Antonio	Atlantic Ocean	1 27 0 N	7 26 0 E	
Prince Edward's Islands, S. End	Indian Ocean	46 53 0 S	37 46 0 E	
Prince Edward's Isle, Chs. Town	Gulf of St. Lawrence	46 14 0 N	62 56 0 W	
Prince of Wales Fort	Davis's Straits	58 47 32 N	94 13 55 W	7 20
Providence	United States	41 50 40 N	71 25 45 W	
Providence Island, Nassau Light	Lucayos	25 5 18 N	77 19 0 W	7 30
Pulo Laut, Great, N. E. Point	Macassar Straits	3 23 0 S	116 41 0 E	
Pylstaart Island	Friendly Isles	22 23 30 S	175 49 30 W	
Quebec Citadel	Canada	46 49 12 N	71 16 0 W	7 30
Queen Charlotte's Sound	New Zealand	41 5 57 S	174 40 0 E	9 0
Quiloa	E. Coast of Africa	8 41 0 S	39 47 0 E	3 45
Quiros Island	Friendly Isles	10 40 0 S	169 54 0 W	
Quito	Peru	0 14 0 S	78 45 6 W	
Race Cape	Newfoundland	46 40 0 N	53 3 15 W	
Ram Head	England	50 18 52 N	4 12 29 W	5 45
Ramea Isles	Newfoundland	47 32 0 N	57 24 0 W	
Ranai	Sandwich Isles	20 46 30 N	156 55 30 W	
Raoul Island, N. W. Point	Pacific Ocean	29 15 45 S	181 56 0 E	
Rasal, ad, Cape	Arabia	22 33 0 N	59 43 0 E	
Rattan Island, East Point	Bay of Honduras	16 26 0 N	86 20 0 W	
Recreation Island	Pacific Ocean	15 58 0 S	148 48 0 W	
Redondo Island	Carribee Isles	17 1 0 N	62 19 0 W	
Resolution Island	Pacific Ocean	17 23 0 S	141 45 30 W	
Resolution Cape	Hudson's Straits	61 29 0 N	65 10 0 W	7 0
Rhe Island Light	France	46 14 49 N	1 33 25 W	3 0
Rhode Island Light	United States	41 27 0 N	71 24 0 W	7 37
Riga	Russia in Europe	56 57 10 N	24 5 45 E	
Rio Janeiro Bay, Rat Island	Brazil	22 53 0 S	43 12 0 W	2 5
Roca, N. E. Point	Leeward Islands	11 58 30 N	66 42 20 W	
Roca Partida Island	Pacific Ocean	18 30 0 N	114 2 0 W	
Roca Partida Point	Mexico	18 44 0 N	94 58 0 W	
Rochefort Hospital	France	45 50 40 N	0 57 34 W	3 0
Rochelle	France	46 9 21 N	1 9 40 W	3 45
Rodrigue Island	Indian Ocean	19 40 40 S	63 11 45 E	0 45
Roge (Great) Light	Gulf of Finland	59 25 0 N	24 5 0 E	
Roman Cape	Terra Firma	12 11 0 N	70 8 0 W	
Rome, Roman College	Italy	41 53 54 N	12 27 7 E	
Ronaldsha, N. Point	Orkney Islands	59 23 0 N	2 34 0 W	10 30
Rondo Island	Bay of Bengal	6 4 30 N	95 14 0 E	
Roque (St.) Cape	Brazil	5 28 17 S	35 17 0 W	
Rotterdam	Netherlands	51 55 22 N	4 29 11 E	3 30

TABLE XXXV.

Latitudes and Longitudes of Places, &c

Places.	Coast, Sea, or Country.	Latitude.	Longitude.	Time H. W.
Rotuma Island	Pacific Ocean	12° 30′ 0″ S	177° 50′ 0″ E	
Rouen Cathedral	France	49 26 27 N	1 5 59 E	1 0
Rour Island	Pacific Ocean	1 33 40 S	143 12 45 E	
Saba Island, Ladder Point	Carribee Isles	17 39 30 N	63 20 40 W	
Sable Cape	Nova Scotia	43 23 45 N	65 38 0 W	8 0
Sable Cape	Florida	25 2 0 N	81 15 0 W	
Sable Island, East Point	Nova Scotia	44 4 0 N	60 30 0 W	8 30
Saldanah Bay, Entrance, N. Point	W. Coast of Africa	33 2 0 S	17 48 30 E	
Sallee	Morocco	34 2 45 N	6 44 35 W	
Salisbury Island	Hudson's Bay	63 29 0 N	76 47 0 W	11 0
Salt Island, S. Point	Cape Verd Isles	16 31 25 N	23 0 0 W	
Salvador (St.) or Bahia	Brazil	13 0 50 S	38 32 0 W	3 45
Salvages Isles, Largest	Atlantic Ocean	30 8 0 N	15 55 0 W	
Samana Island, E. Point	Lucayos	23 12 0 N	73 35 0 W	
Samar Island, Cape Esper Santo	Philippine Isles	12 35 0 N	125 17 0 E	
Samarang Bay	Java	6 53 0 S	110 34 0 E	
Sandalwood Island, E. Point	Indian Archipelago	10 0 0 S	120 35 0 E	
Sanders's (Sir C.) Island	Society Isles	17 25 0 S	150 58 0 W	
Sandwich Bay, Entrance	Labrador	53 48 0 N	56 42 0 W	9 0
Sandwich Cape	New Holland	18 19 0 S	146 29 0 E	
Sandwich Harbour	Nova Scotia	45 8 0 N	61 36 0 W	9 0
Sandwich Island	New Hebrides	17 41 0 S	168 33 0 E	
Sandy Cape	New Holland	24 42 0 S	153 16 0 E	
Sandy Hook Light	United States	40 27 30 N	74 0 0 W	7 30
Sandy Island	Indian Ocean	15 52 0 N	54 50 0 E	
Santa Cruz	W. Coast of Africa	30 30 0 N	9 38 0 W	
Santa Cruz Harbour	Patagonia	50 17 30 S	68 28 0 W	
Santa Cruz Island, Cape Byron	Pacific Ocean	10 43 0 S	166 9 0 E	
Sapata Island, East Point	Chinese Sea	10 4 30 N	109 13 15 E	
Savage Island	Pacific Ocean	19 2 15 S	169 30 30 W	
Savanna Light	United States	32 0 0 N	80 57 5 W	11 15
Savanna la Mer	Jamaica	18 13 0 N	78 15 0 W	
Savu Island, Centre	Indian Archipelago	10 30 0 S	121 43 0 E	
Scarborough Shoal	Chinese Sea	15 8 30 N	117 48 0 E	
Scilly Isles, St. Mary's	England	49 54 30 N	6 17 0 W	4 40
Scio Island, Town	Archipelago	38 24 0 N	26 0 0 E	
Schowen Light	Holland	51 39 0 N	3 37 0 E	
Seal Island, South Point	United States	43 25 25 N	66 0 35 W	8 45
Sebastian (St.) Cape	E. Coast of Africa	22 5 0 S	35 58 0 E	
Se Booro Island, S. E. Point	W. Coast of Sumatra	1 47 0 S	99 14 0 E	
Senegal River, Entrance	W. Coast of Africa	15 55 20 N	16 32 30 W	10 30
Se Pora, Pt. Marlborough	W. Coast of Sumatra	2 25 0 S	99 58 0 E	
Shetland Isles, (New) Cape Smith	Atlantic Ocean	62 52 30 S	63 45 0 W	
Siam River, Entrance	Malacca	13 29 40 N	101 15 0 E	
Sierra Leone Cape	W. Coast of Africa	8 30 0 N	13 18 0 W	8 15
Skagen Cape Light, Scaw	Denmark	57 43 44 N	10 36 50 E	
Smith's Isles	Pacific Ocean	14 30 30 N	168 42 15 E	
Smyrna, Centre	Turkey in Europe	38 27 20 N	27 8 30 E	
Snare's Island	Pacific Ocean	48 3 0 S	166 20 0 E	
Soccorro Island	Pacific Ocean	18 40 0 N	110 17 0 W	
Socotra Island, N. E. Point	Arabian Sea	12 43 0 N	53 18 0 E	9 0
Solitary Island	Friendly Isles	10 40 0 S	176 0 0 W	
Solombo Island (Great)	Indian Archipelago	5 33 0 S	114 28 0 E	
Solomon Cape	Candia	35 9 15 N	26 19 55 E	
Sooloo Island, Sooloo Town	Indian Archipelago	6 1 0 N	121 12 0 E	
South Cape	Spitzbergen	76 32 0 N	13 45 0 E	
South Cape	New Zealand	47 16 50 S	167 20 9 E	
South Cape	Van Dieman's Land	43 37 0 S	146 49 0 E	
South Isle	Pacific Ocean	31 30 0 N	140 0 0 E	
Southampton Island, C. Pembroke	Hudson's Bay	62 57 0 N	81 59 45 W	

TABLE XXXV.

Latitudes and Longitudes of Places, &c.

Places.	Coast, Sea, or Country.	Latitude.	Longitude.	Time H. W.
Southern Thule	Sandwich Land	59°34′ 0″S	27°45′ 0″W	
Spartel Cape	Barbary	35 48 30 N	5 53 0 W	3 0
Spartivento Cape	Italy	37 55 50 N	16 3 35 E	
Speaker's Bank	Indian Ocean	4 48 0 S	72 30 0 E	
Sproe Island	Denmark	55 20 0 N	10 59 0 E	
Stapel's (E.) Light	England	55 38 9 N	1 37 5 W	2 30
Start Point	England	50 13 26 N	3 38 21 W	5 55
Staunton's Island	China	36 47 0 N	122 13 0 E	
Steen Ground	Atlantic Ocean	32 45 0 N	21 25 0 W	
Stephen's Cape	Behring's Straits	63 33 30 N	162 17 0 W	
Stettin	Germany	53 23 0 N	14 34 0 E	
Stockholm Observatory	Sweden	59 20 31 N	18 3 30 E	
Stromboli Island, St. Bartolo	Mediterranean	38 48 20 N	15 12 30 E	
Stromness	Orkneys	58 57 0 N	3 28 30 W	9 0
Success Cape	Terra del Fuego	55 0 0 S	65 19 0 W	4 30
Sulphur Island	Chinese Sea	27 52 0 N	128 22 0 E	
Surat River, Vaux's Tomb	India	21 4 30 N	72 51 30 E	4 20
Surigao Isles, Surigao Town	Philippine Isles	9 47 0 N	125 25 0 E	
Suwarrow Isles	Pacific Ocean	13 13 15 S	163 31 4 W	
Swan's Island, largest	Van Dieman's Land	40 43 0 S	148 8 0 E	
Swan Isles	Bay of Honduras	17 22 0 N	83 56 0 W	
Sweetnose Cape	Russia in Europe	68 12 0 N	39 46 0 E	0 0
Syracuse Light	Sicily	37 2 58 N	15 16 10 E	
Table Bay, Robin Island	S. Coast of Africa	33 48 0 S	18 17 30 E	2 30
Table Island	New Hebrides	15 38 0 S	167 7 0 E	
Tahoorowa Island	Sandwich Isles	20 38 0 N	156 36 30 W	
Tambelan Isles, Centre	Indian Archipelago	1 0 0 N	107 36 0 E	
Tanakeke Island	Indian Archipelago	5 52 0 S	119 19 0 E	
Tanna Island, Port Resolution	New Hebrides	19 32 25 S	169 41 0 E	3 0
Taoukaa Island	Pacific Ocean	14 30 39 S	145 9 30 W	
Tarbett Ness	Scotland	57 54 0 N	3 44 36 W	
Taya Island	Indian Archipelago	0 45 30 S	104 58 0 E	
Taya Island, Northernmost	Chinese Sea	19 56 0 N	111 10 0 E	
Taypingshan, N. E. Point	Chinese Sea	24 30 0 N	125 6 0 E	
Tchin San Isles	China	30 20 0 N	122 36 0 E	
Telemaque Shoal	Indian Ocean	38 11 0 S	21 58 0 E	
Teneriffe Island, Santa Cruz Mole	Canary Isles	28 27 54 N	16 15 0 W	
Tercera Island, Angra	Azores	38 39 0 N	27 13 0 W	11 45
Testigos Isles	Carribee Sea	11 23 0 N	63 10 30 W	
Texel S. Point	Holland	53 2 0 N	4 33 0 E	7 45
Thomas (St.) Island, Harbour	Carribee Isles	18 20 30 N	65 3 6 W	
Thomas (St.) Island	Atlantic Ocean	0 27 0 N	6 44 40 E	
Tiburon Cape	St. Domingo	18 19 25 N	74 34 0 W	
Timoan Island, N. Point	Indian Archipelago	2 54 0 N	104 15 0 E	
Timor Island, Coupang	Indian Archipelago	10 10 0 S	123 36 0 E	
Timor Island, Delhi	Indian Archipelago	8 35 0 S	125 40 0 E	
Tinhosa Island	Chinese Sea	18 46 0 N	110 29 0 E	
Tinmouth Light	England	55 0 55 N	1 24 31 W	3 0
Tobago Island, N. E. Point	Carribee Isles	11 10 13 N	60 27 15 W	
Tongatabou Island, Panghaim I.	Friendly Isles	21 7 35 S	175 12 59 W	6 50
Toobuai Island	Pacific Ocean	23 25 0 S	149 20 30 W	
Torbay	Nova Scotia	45 12 0 N	61 16 0 W	
Tortola Bay	Virgin Isles	18 23 30 N	64 39 0 W	
Tortudas, E. Point	St. Domingo	20 0 55 N	72 35 55 W	
Tortuga Island, Centre	Carribee Sea	10 59 0 N	65 34 13 W	
Toulon Observatory	France	43 7 30 N	5 56 41 E	
Tory Island, N. W. Point	Ireland	55 17 30 N	8 16 0 W	
Trafalgar Cape	Spain	36 9 10 N	6 0 20 W	
Triangle Isles	Indian Archipelago	3 1 0 S	117 53 0 E	
Triangle Isles, E. Isle	Gulf of Mexico	21 2 0 N	92 5 0 W	

Latitudes and Longitudes of Places, &c.

Places.	Coast, Sea, or Country.	Latitude.	Longitude.	Time H. W.
Trieste Island	W. Coast of Sumatra	4° 2′ 0″S	101°22′ 0″E	
Trieste Town	Gulf of Venice	45 38 8 N	13 47 8 E	
Trincomalé, Flagstaff	Ceylon	8 35 30 N	81 22 0 E	6 0
Trinidad Island, S. Point	Atlantic Ocean	20 31 0 S	29 21 40 W	
Trinidad Island, Port d'Espagne	Carribee Isles	10 39 15 N	61 34 15 W	
Tristan d'Acunha Island	Atlantic Ocean	37 5 36 S	12 16 0 W	
Triton Island	Chinese Sea	15 46 0 N	111 11 0 E	
Truxillo	Mexico	15 51 0 N	86 7 0 W	
Truxillo	Peru	8 6 9 S	79 3 10 W	
Tsus Sima Island, N. Point	Japan Sea	34 40 30 N	129 27 7 E	
Turtle Island	Pacific Ocean	19 48 45 S	177 57 0 W	
Turtle Isles	Indian Archipelago	5 25 0 S	127 38 0 E	
Ulietea Island	Society Isles	16 45 35 S	151 31 0 W	11 20
Unst Island	Shetland	60 45 25 N	1 1 0 W	
Uraniburg	Denmark	55 54 38 N	12 41 59 E	
Ushant Island, Light	France	48 28 8 N	5 3 6 W	4 30
Ustica Island, Turk's Peak	Mediterranean	38 44 45 N	13 11 30 E	
Valery sur Somme (St.)	France	50 11 21 N	1 38 0 E	10 30
Valparaiso	Chili	33 1 55 S	71 43 15 W	
Varela Island	Straits of Malacca	3 47 0 N	99 36 0 E	
Vavao Island	Pacific Ocean	18 33 54 S	173 59 45 W	
Vendola Island	Admiralty Isles	2 14 0 S	148 10 7 E	
Venice, St. Mark's	Italy	45 25 56 N	12 20 29 E	
Vera Cruz	Mexico	19 11 52 N	96 8 45 W	
Verd Cape	W. Coast of Africa	14 43 45 N	17 32 30 W	
Victory Cape	Terra del Fuego	52 16 10 S	74 51 0 W	
Vigo	Spain	42 14 46 N	8 34 30 W	
Villa Franca, Light	Italy	43 40 30 N	7 19 50 E	
Vincent (St.) Island	Cape Verd Isles	16 51 0 N	25 4 0 W	
Vincent (St.) Cape	Portugal	37 2 54 N	8 59 36 W	2 15
Vincent (St.) Island, Kingston	Carribee Isles	13 11 0 N	61 16 0 W	
Virgin Gorda Island, E. Cape	Carribee Isles	18 31 7 N	64 25 24 W	
Virgin's Cape	Patagonia	52 18 35 S	68 17 25 W	12 0
Virgin Rocks	Newfoundland	47 9 0 N	54 5 0 W	
Vizagapatam	India	17 42 30 N	83 26 0 E	
Volcano Island	Pacific Ocean	10 25 12 S	165 48 21 E	
Volcano Island, Cape Guardiano	Mediterranean	38 21 5 N	14 58 15 E	
Walcheren Island, W. Point	Holland	51 32 0 N	3 25 0 E	
Wallis's Island	Pacific Ocean	13 18 0 S	177 21 45 W	
Walpole's Island	New Hebrides	22 39 0 S	169 16 0 E	
Walsingham Cape	Cumberland Isles	66 4 0 N	60 51 0 W	
Walwich Bay	W. Coast of Africa	22 52 30 S	14 22 6 E	1 54
Wardhuus	Lapland	70 22 36 N	31 7 0 E	4 0
Washington, Capitol	United States	38 53 25 N	77 2 0 W	
Watcher, (N.) Island	Indian Archipelago	5 12 30 S	106 32 0 E	
Wateeoo Island	Pacific Ocean	20 1 30 S	158 14 30 W	
Waterford	Ireland	52 13 0 N	7 10 0 W	5 30
Waygate Island	Baffin's Bay	70 26 17 N	54 51 49 W	
Webuck Cape	Labrador	54 55 0 N	57 40 0 W	
Weigate's Straits	Russia in Europe	70 50 0 N	57 45 0 E	
Werro Island	Lapland	67 42 0 N	11 25 0 E	
Western Port, C. Shank	New South Wales	38 31 3 S	144 52 0 E	
Westra Island, Noup Head	Orkney Islands	59 19 0 N	3 13 0 W	
Wetter Island, East Point	Indian Archipelago	7 46 0 S	126 54 0 E	
Wexford Harbour	Ireland	52 22 0 N	6 19 0 W	7 30
Whitehaven Windmill	England	54 32 50 N	3 34 56 W	11 15
Whitby	England	54 28 30 N	0 36 30 W	3 45
Whitsunday Island	Pacific Ocean	19 26 0 S	138 12 0 W	

TABLE XXXV.

Latitudes and Longitudes of Places, &c.

Places.	Coast, Sea, or Country.	Latitude.	Longitude.	Time H. W.
Whitsuntide Island	New Hebrides	15°44′ 0″S	168°20′ 15″E	
Wicklow Light	Ireland	52 59 0 N	6 0 21 W	9 0
Woahoo Island	Sandwich Isles	21 40 30 N	158 1 5 W	
Wolf Island	Labrador	53 42 0 N	55 36 0 W	
Woodham's Isles	Newfoundland	49 55 0 N	53 30 0 W	
Woody Point	W. Coast of America.	50 6 3 N	127 57 0 W	
Wylingoe (Great) Light	Norway	59 4 0 N	5 21 30 E	
Xam Hay	China	31 16 0 N	121 32 0 E	
Xulla (Great) S. End	Indian Archipelago	1 51 0 S	124 52 0 E	
Yap Island	Pacific Ocean	9 35 0 N	138 8 0 E	
Yellow River, Entrance	China	34 3 0 N	120 0 0 E	
York (New) Battery	United States	40 42 6 N	73 59 0 W	8 54
York Fort	New Wales	57 1 48 N	92 34 45 W	9 10
York Island, Mount Adolphus	Torres' Straits	10 36 30 S	142 40 0 E	
Zacheo Island	Porto Rico	18 23 48 N	67 34 1 W	
Zante Island, Town	Mediterranean	37 47 17 N	20 54 42 E	
Zanzibar Fort	E. Coast of Africa	6 9 36 S	39 9 24 E	4 30
Ziaret Cape	Syria	35 37 0 N	35 34 0 E	

TABLE XXXVI.

THE TIME OF HIGH WATER.

On the Full and Change of the Moon, at the principal Ports and Places on the Coasts of Great Britain and Ireland, with the rise of the Spring Tide, in Feet.

Places.	Situation.	Time H. W.	Rise Feet.	Places.	Situation.	Time H. W.	Rise Feet.
Aberdeen	Scotland	1 6		Boston	England	7 15	
Aberdovy	Wales	7 30	13	Brassa Sound	Shetland	10 0	8
Aberistwith	Wales	7 30	13	Bree Bank	North Sea	3 30	
Achill Head	Ireland	6 0		Bridgewater	England	6 45	22
Agnes (St.)	Scilly Isles	4 10	18	Bridlington	England	4 30	13
Air Point	Isle of Man	10 30		Bridport	England	6 0	
Aldborough	England	10 45	10	Brighton	England	10 0	10
Alne River	England	2 45		Bristol	England	7 0	42
Amlwick Point	Anglesea	10 30	24	Burnt Island	Scotland	2 30	14
Arran Isle	Scotland	11 15	9				
Arundel Bar	England	11 15	16	Caernarvon Bar	Wales	9 0	22
				Cairston	Orkney	9 0	12
Balta	Shetland	3 0	6	Calf of Man	St. Geo. Chan.	10 30	
Baltimore	Ireland	3 45	12	Cantire (Mull)	Scotland	9 0	5
Bamff	Scotland	11 30		Cardigan Bar	Wales	7 0	20
Bantry Bay	Ireland	3 45	11	Carlingford	Ireland	9 0	14
Barmouth	Wales	8 0	13	Carmarthen	Wales	6 10	24
Barnstaple Bar	England	5 30	26	Chatham	England	1 0	
Beachy, on Shore	England	10 15	20	Chester Bar	England	10 30	26
Beachy Offing	England	11 0		Chichester Harb.	England	11 30	18
Beaumaris	Wales	10 15	24	Clear Cape	Ireland	4 30	11
Berwick	England	2 18	16	Cornwall Cape	England	4 25	22
Blakeney Harbour	England	6 50	16	Cork Harb. Ent.	Ireland	4 30	18
Blythe	England	2 45	12	Cowes	Isle of Wight	10 45	15
Bolt Head	England	5 55	20	Cromartie	Scotland	11 45	14

THE TIME OF HIGH WATER, &c.

Places.	Situation.	Time H. W.	Rise Feet.	Places.	Situation.	Time H. W.	Rise Feet.
Cuckold's Point...	River Thames.	1 52	18	Margate Pier	England	11 15	16
				Milford Haven, Ent.	England	5 45	36
Dartmouth	England	6 10	20	Montrose	Scotland	1 40	
Deal	England	11 25	19	Mount's Bay	England	4 45	19
Dee (River)	Scotland	0 45	26				
Dingle Bay	Ireland	3 30	11½	Needles	England	9 45	9
Dover Pier	England	11 16	20	Newcastle	England	4 0	
Downs	England	11 15	15	Nore Light.....	River Thames.	1 9	14
Dublin Bar	Ireland	10 30	12				
Dudgeon Lights ..	North Sea ...	7 30		Orfordness	England	10 40	11
Dunbar	Scotland	2 15		Orkney Isles	Scotland	10 30	8
Dundalk Bay	Ireland	10 45					
Dundee.....	Scotland.....	2 15		Pentland Frith	Scotland	10 30	8
Dungarvon	Ireland	4 30		Penzance	England	4 30	19
Dungeness	England	10 50	24	Plymouth Sound ..	England	5 30	18
				Portland Race	England	9 15	7
Eddystone	English Chan.	5 15	18	Portland Road	England	6 15	
Exmouth Bar.....	England	6 25	14	Portsmouth Har. ..	England	11 36	18
Eyemouth	Scotland	2 15					
Falmouth	England	5 30	18	Ramsgate	England	11 50	21
Flamboro' Head...	England	4 30		Rye Harbour	England	10 36	24
Flats (Kentish) ...	England	11 0					
Foreland (N.).....	England	11 45	16	Saltees	Ireland	5 40	12
Foreland (S.).....	England	11 20	15	Seaford.....	England	10 16	20
Fowey	England	5 30	16	Selsea Harbour....	England	11 15	15
				Shannon R. Ent. ..	Ireland	3 45	12
Galloper	River Thames.	0 45		Sheerness.....	England	0 40	15
Galway Bay	Ireland	4 30		Shields	England	3 0	13
Galloway (Mull) ..	Scotland	11 15		Skerries	Ireland	4 45	11
Goodwyn	Downs	1 30		Sligo Bay	Ireland	6 45	
Gravesend.....	England	1 30	16	Solebay	England	10 30	7
Gunfleet	River Thames.	12 0		Southampton	England	11 40	18
Hartlepool.....	England.....	3 45		Spithead	England	9 30	
Harwich.....	England	11 30	14	Sunderland.....	England	3 0	12
Hastings.....	England	10 36		Swansea	Wales.....	6 0	30
Helen's (St.)	England.....	11 0	16	Swin.....	River Thames.	12 0	16
Holyhead Bay	Wales.....	10 0	24				
Hull	England	6 0	18	Tay Bar	Scotland	1 45	
Humber R. Ent....	England	5 15	18	Tees River	England	3 30	16
				Tinmouth Bar	England	2 50	13
Ipswich.....	England	12 0		Torbay	England	6 0	20
Ives (St.)	England	4 30	22	Tralee Bay	Ireland	3 45	
Kenmare River ...	Ireland	3 30	11	Waterford Harb. ..	Ireland	5 30	13
Kentish Knock ...	River Thames.	11 30		Wexford Harbour..	Ireland	7 30	
Kinsale Harbour...	Ireland	4 30		Weymouth	England	6 30	7
Kircudbright	Scotland	11 15		Whitby.....	England	3 45	13
				Wicklow	Ireland	9 0	
Land's End	England	4 30		Wisbeach	England	7 30	
Leith Pier	Scotland	2 20	15				
Lewis Islands	Scotland	6 0	11	Yarmouth Roads ..	England	8 40	8
Liverpool Dock ...	England	11 20	27	Yarmouth Sands ..	England	10 30	
London Bridge....	England	2 7	19	Yorkshire Coast...	England	6 0	
Lyme Regis	England	6 45	13	Youghall.....	Ireland	5 0	11

EXPLANATION

OF

THE MANNER OF USING THE TABLES.

Tables I. and II.—*Difference of Latitude and Departure.*

These Tables contain the parts of right angled plane triangles, whose greatest sides are integers, not exceeding 300; the angles in Table I. being given to every quarter point of the compass, and those in Table II. to every degree of the quadrant. If the sides of the proposed triangle should exceed the limits of the Table, they may be divided by any number that will bring them within these limits; and then the results from the Table, multiplied by the same number, will give the required parts of the proposed triangle; observing that the angles must in no case be multiplied or divided.

These are very useful tables in the practical resolution of problems in which right angled plane triangles are concerned, *when minute accuracy is not required;* and from their use in facilitating the reduction of compound courses to single ones, they are called *Traverse Tables.*

Each angle at the top or the bottom of the page may be considered as the vertical angle of a right angled plane triangle; and the side opposite that angle is found in the column marked *Dep.*, the other side in the column marked *Lat.*, and the hypothenuse in the column marked *Dist.*, all adjoining each other on the same line.

Thus with the vertical angle 28° and the base **92**, the perpendicular is found 173·1, and the hypothenuse 196. With the perpendicular 114·1 and the base 163, the vertical angle is found 55° and the hypothenuse 199.

With a course of $3\frac{1}{4}$ points and a distance of 215, the difference of latitude is found 172·7, in the column of *Lat.*, and the departure 128·1, in the column marked *Dep.* With a middle latitude 39° considered as the vertical angle of a right angled plane triangle, and a departure of 141·2, considered as the perpendicular of the same triangle, we have the difference of longitude nearly 182, as the hypothenuse in the column of *Dist.* With a course of 18° and a meridional difference of latitude of 217 in the column of *Lat.*, we have in the column of *Dep.* nearly 70·5 for the difference of Longitude.

Table III.—*Meridional Parts.*

This Table is used in laying down the meridians in the construction of charts according to Mercator's projection of the globe, and also in the solution of problems on the principle of that projection. The degrees of latitude are found at the top of the Table, and the minutes in the side column. Under the degrees, and opposite the minutes, stand the meridional parts. Thus, for latitude 48° 12′, the meridional parts are 3309.

Table IV.—*Log. Sines, &c. to every Quarter Point of the Compass.*

When the course is given, or required, in points of the compass, the log. sine, tangent, &c. to the given course, or the required course to a given log. sine, tangent, &c. may be found from this Table. The points, &c., if not exceeding four, are found in the left-hand column; and in that case the denomination *sine, tangent,* &c. of the log. is to be looked for at the top of the Table. If the points exceed four, they will be found in the right-hand column; and the denomination of the required numbers at the bottom of the Table.

Thus the log. sin. of $2\frac{1}{4}$ points is..... 9·673387
tan. of $5\frac{3}{4}$.....10·325171

Table V.—*Logarithms of Numbers.*

This Table contains the decimal part of the logarithm of every integer below 10,000, carried to six places of figures. The index of the logarithm is easily supplied, as it is always less by one than the number of digits in the integral part of the number. If the number consist wholly of decimals, the index of the logarithm is then *negative*, and it is indicated by the place occupied by the first figure in the decimal. Thus the index of the logarithm of ·04 is — 2; of ·006, — 3, &c. But to avoid the confusion that might arise by the addition and subtraction of negative indices, it is customary to take the arithmetical complement of the negative indices, and to consider these complements as positive. Thus 8 is put as the index of ·04, 7 as the index of ·006, &c.

To find the Logarithm of any Number.

If the number consist of only one or two figures, its logarithm will be found at once in the first page of the Table. Thus, in the column marked No., we find 66, and in the adjoining column marked Log. we have 1·819544, which is the log. of 66. And in the same way, opposite 7 we find ·845098, the log. of 7.

If the number consist of three figures, the decimal part of its logarithm may also be found at once. For if the number be found in the column marked No., the decimal part of its logarithm will be found in the adjoining column under 0. Thus the decimal part of the log. of 382 is ·582063; and as the number consists of *three digits*, the index of the logarithm is 2; therefore the log. of 382 is 2·582063. It must be observed that when there is a blank space in the column of logar thms, the figures immediately above it are to be understood as repeated in every line below

If the number consists of four figures; opposite the first three figures, in the No. column, and below the fourth figure, at the top of the Table, is the decimal part of the logarithm. Thus, to find the log. of 7218; we have opposite 721 in the No. column, and below 8 at the top of the Table, 858417, for the decimal part of the required logarithm. And as 7218 consists of four digits, the index of its logarithm is 3; and therefore the log. of 7218 is 3·858417.

If the number consist of five figures, or more; seek the decimal part of the log. of the first four figures, as above; then multiply the number from the column marked *Diff.* on the right of the Table, by the remaining digits of the given number; strike off as many figures from the right of the product as are contained in the number by which you multiply; add the remaining figures of the product to the decimal part of the log. of the first four digits already found, and the proper index being prefixed to the sum, you will have the required logarithm.

Let it be required, as an example, to find the logarithm of 682473. With 6824 we find ·834039; and in the column of Diff. on the right, we have 64. Now 64 multiplied by 73, the remaining digits of the proposed number, gives 4672. And if the last two figures be rejected, we have 46, or nearly 47, to add to ·834039. The sum, with the proper index 5, is 5·834086, the required log. of 682473.

To find the Number corresponding to a given Logarithm.

The index will always show how many digits are contained in the integral part of the required number; and if the number of digits required do not exceed four, the number will be found in the Table without trouble. For seek the nearest logarithm in the Table to that which is given, and the first three digits of the required number will be found on the same line in the column of No., and the fourth figure at the top of the Table, over the nearest logarithm. Thus the No. to 3·426874 is 2672, the No. to 2·993877 is 986, and the No. to 0·874123 is 7·484, &c.

But if the number be required to a greater number of places than four, take the number answering to the next less logarithm, and to the difference between that logarithm and the given one, affix as many cyphers as there are digits wanted above four, and divide the result by the Diff. taken from the same line as the logarithm, and the quotient will be the remaining figures of the required number.

For example, let the number to log. 4·827639 be required to six places of figures. The log. in the Table next less than the given one is ·827628, to which the corresponding number is 6724. Now this logarithm, taken from the given logarithm, leaves a remainder of 11; and as six figures are required in the answer, two cyphers must be annexed to this remainder.

We have thus 1100 to be divided by 65, the difference in the right-hand column of the Table. The quotient is nearly 17. Hence 672417 are the digits in the required number, and as the index of the logarithm is 4, the number must contain five figures in integers; and therefore 67241·7 is the required number.

Table V.*—*To find the hour angle from Altitudes.*

This Table is intended to facilitate the computation of time; the logarithms in it are twice the log. sines of half the hour angles, for such distances from the meridian as observations for time may with propriety be taken; but the times in the Table are the *whole* hour angles or meridian distances reckoned westerly.

Having found the log. for Table V.* according to the rule, page 243, as exemplified in the examples on pages 244 and 245; if the altitude is *decreasing* take the hour at the top and the minute on the left which on the Table corresponds with the log. next *less* than the given one, and to the difference between that next less and the given logarithm annex two ciphers, and divide by the adjoining *diff.* to 100 *sec.* in the Table, and the quotient will be the seconds in the required hour angle. If decimals of seconds are required, add more ciphers and continue the division.

When the altitude is increasing take the hour at the bottom and the minute on the right which in the Table corresponds with the logarithm next greater than the given one, and to the difference between that next greater and the given logarithm annex two ciphers, and proceed as above for seconds and decimals.

Table VI.—*Log. Sines, Tangents, &c.*

When the degrees in this Table are found at the top, the denomination of the log. will also be found at the top, and the minutes of the arc in the column on the left; but when the degrees are found at the bottom, the name of the log. will be found at the bottom, and the minutes of the arc in the column on the right. The column marked Diff. is the change of either of the logarithms between which it is placed, corresponding to a change of 100″ in the arc. The decimals in the logarithms are carried to six places of figures, an extent quite adequate to the solution of any problem to which in this work it is proposed to apply them.

When the log. *sine* of an obtuse angle is required, take the *cosine* of its complement or of the difference between it and 90°; when the log. *cotangent* of an obtuse angle is required, take the log. *tangent* of its complement, &c. Thus, instead of seeking for the secant of 121° 4′ 20″, an arc which is not to be found in the Table, seek the cosecant of 31° 4′ 20″.

Examples.

Log. sine..of,.....	40° 4′	is	9·808669
cosine.....	21 38	..	9·968278
tangent.....	84 13	..	10·994466
cotangent....	55 58	..	9·829532
secant.....	70 20	..	10·472954
cosecant	8 35	..	10·826092
Cosine 143° 24′ = sine	53 24	is	9·904617

In this manner may the *log. sine, tangent,* &c. be taken out for degrees and minutes. If the given arc contain seconds also, the proportional part of the logarithm for them may be obtained thus: Multiply the number taken from the column of Diff. between the given and the next following minute, by the number of seconds; reject two figures from the right of the product, and add the remaining figures to the log. corresponding to the given degrees and minutes, when the logarithm is increasing, but subtract them when the logarithm is decreasing, and the sum or the difference will be the required logarithm.

Example.—What is the log. cotangent of 36° 34′ 27″?

The log. cotangent of 36° 34′ is 10·129735, and the logarithms in the column decrease as the arc increases; therefore the log. cotangent of 36° 34′ 27″ is less than the log. cotangent of 36° 34′. Now the number in the corresponding column of Diff. between 34′ and 35′ is 440; which, multiplied by 27, and the two figures on the right rejected from the product, gives 119; and this number subtracted from 10·129735, leaves 10·129616 for the cotangent of 36° 34′ 27″.

When the log. sine, tangent, &c. is given to find the corresponding arc, we have only to reverse the above process. If the arc is required only to the nearest minute, seek in the proper column for the logarithm which differs least from the given one, and take out the degrees and minutes corresponding to that logarithm.

Thus the arc to log. sine.. 9·863724 is 46° 57′
secant 10·101003 .. 37 35

But if the seconds in the arc are also required, we seek in the proper column for the logarithm which is next less than the given one, when the logarithms in the column are increasing, but next greater when the logarithms in the column are decreasing, and take the degrees and minutes corresponding to that logarithm for the degrees and minutes in the required arc. Then to the difference between the logarithm so found and the given logarithm we annex two ciphers, and divide the result by the number taken from the corresponding part of the adjoining column of Diff. and the quotient is the seconds to be added to the degrees and minutes before taken out.

Example.—Required the arc to log. sine 9·641357 ?

The sine of 25° 58′ is 9·641324, and it is the logarithm *next less* than the given one, which we take, as the logarithms in the column increase with the arc. The difference of these two logarithms is 33, and if two ciphers be affixed to the difference, and the number then be divided by 432, taken from the column of Diff. in the Table, we have nearly 8 for the number of seconds; and hence the required arc is 25° 58′ 8″.

Again, let the arc corresponding to log. cosine 9·126624 be required?

Here we take out 9·127060, the log. cosine of 82° 18′, as it is the log. cosine in the Table *next greater* than 9·126624, the log. cosines decreasing as the arc increases. The difference between these two logarithms is 564; whence 56400 divided by 1559, the number from the column of Diff. gives 36 for the number of seconds. Hence the required arc is 82° 18′ 36″.

The above observations may be sufficient to show, in a general way, the manner of using the Table. But in small arcs, the differences of the log. sines and cosecants are very large and irregular; and in arcs near a quadrant, the cosines and secants have like large and irregular differences; and so in both cases have the tangents and cotangents. The logarithms of such arcs taken from the Table by even proportions will, therefore, frequently not be sufficiently correct. The following rules first given by Dr. Maskelyne, may in such cases be applied with advantage.

To find the Log. Sine of a small Arc.

Add 4·685575 to the common logarithm of the arc reduced to seconds; from the sum subtract one-third of the log. secant less radius of the arc, and the remainder will be the required log. sine.

To find the Log. Tangent of a small Arc.

Add together the common logarithm of the arc, reduced to seconds, two-thirds of the log. secant less radius of the arc, and 4·685575, and the sum will be the required tangent. We have, hence, the following rules for performing the reverse operations.

To find a small Arc whose Log. Sine is given.

To one-third of the log. secant of the arc in the Table, whose log. sine most nearly corresponds with the given log. sine, add the given log. sine, and 5·314425, and the sum will be the common log. of the seconds in the required arc.

To find a small Arc when its Log. Tangent is given.

To the log. tangent add 5·314425, and from the sum subtract two-thirds of the log. secant of the arc in the Table whose tangent most nearly agrees with the given tangent; and the remainder will be the log. of the seconds in the required arc.

Examples.

Required the log. sine of 1° 28′ 13″, or the log. cos. of 88° 31′ 47″ ?

1° 28′ 13″ = 5293″ .... log.	3·723702
Constant No.	4·685575
	8·409277
½ log. sec. 1° . 28′ .....sub.	·000047
1°·28′ 18″ log. sine.....	8·409230

Required the log. tangent 1° 55′ 38″, or log. cotangent 88° 4′ 22″?

1° 55′ 38″ = 6938″.....log.	3·841234
Constant No.....	4·685575
⅔ log. sec. 1° 55½″ .....add	·000163
Ans.	8·526972

Required the arc to log. sine 7·963214?

½ log. sec. 0° 32′	·000006
	7·963214
Constant No.	5·314425
1895″ .....log.	3·277645

Whence the required arc is 31′ 35″.
Hence the arc to log. cosine 7·963214 is 89° 28′ 25″.

Required the arc to log. tangent 8·400138?

	8·400138
Constant No.	5·314425
	3·714563
⅔ log. sec. 1° 26½″...sub.	·000091
5181″ ...log.	3·714472

Required arc 1° 26′ 21″.
Hence the arc to log. cotangent 8·400138 is 88° 33′ 39″.

Table VII.—*Dip of the Sea Horizon.*

This Table contains the depression of the visible horizon arising from the elevation of the eye above the surface of the earth. Opposite to the height of the eye, in feet, is found the dip, in minutes and seconds; and the correction is *subtractive* from altitudes taken by a fore observation, but *additive* to those taken by a back one.

Table VIII.—*Dip of the Sea Horizon at different Distances from it.*

In taking an altitude near land, the line from which the alitude is measured, or that separating the sea and land is sometimes within the horizon, or apparently depressed below it. When the height of the eye, and the distance of the line to which the reflected image of the object observed is brought down, are given, the corresponding dip may be taken from this Table.

Thus if the edge of the sea be one mile distant, and the height of the eye 20 feet; then in the Table opposite one mile, and below 20 feet, stands 12′ the corresponding dip.

Table IX.—*Mean Refraction of Celestial Objects.*

This Table contains the refraction in what is considered a mean state of the atmosphere. The correction is always *subtractive*, and is found opposite to the given altitude.

Thus at the altitude of 13° 20′ the mean refraction is 3′ 57″.

Table X.—⊙*'s Parallax in Altitude.*

The correction from this Table is always *additive* to the altitudes of the sun: it is found opposite to the given altitude.

Table XI.—*Correction of the Mean Refraction.*

When great precision is required, and at all times when the altitude is small, the refractions in Table IX. must be corrected by the numbers in this Table, for the variations in the weight and temperature of the air, indicated by the heights of the barometer and thermometer. The correction for the barometer is *subtractive* when the height of the mercury in the tube is less than 29·6 inches, and additive when it is above; for the thermometer the correction is additive when the temperature is below 50°, but subtractive when it is above.

As an example, let it be required to find the true refraction at the altitude of 6° 10′ the thermometer standing at 64°, and the barometer at 30·3 inches.

By Table IX. at 6° 10′, the mean refraction is.....		8′ 15″
In Table XI. opposite 6° and above 30·3 stands	12″ +	diff... − 4
below 64°	16 −	
True refraction		8 11

This Table is not carried higher than 60° of alt., as above that alt. the corrections are too small to be worth attending to; and it is only continued to 6°, as below that alt. little confidence can be placed in the corrections. For lower altitudes however they may readily be determined approximately by the following Table, observing that the correction for thermometer is + when it is lower, and — when higher than 50°; and that for barometer + when it is higher, and — when lower than 29·6 inches.

Multiply the number corresponding to barometer and the altitude, by the difference between the height of the barometer and 29·6 inches, and the product will be the correction for the height of the barometer.

Multiply the number corresponding to thermometer and the altitude, by the difference between the height of the thermometer and 50°, and the product will be the correction for the thermometer.

Altitude.	5°	4°	3°	2°	1°
Barometer	20″·1	24″·1	30″·0	38″·0	52″·0
Thermometer	1·4	1·7	2·3	3·2	4·7

TABLE XII.—*Reduction of the Moon's Equatorial Parallax.*

The horizontal parallax, as given in the Nautical Almanac, is adapted to the earth's equatorial or greatest radius. This Table contains the reduction to adapt the parallax to any given latitude, computed on the supposition that the equatorial diameter of the earth is to its axis as 300 is to 299.—For example, if the moon's horizontal parallax from the Nautical Almanac were 60′, the parallax for lat. 56° would be 60′ − 8·2″ = 59′ 51·8″.

TABLE XIII.—*Reduction of Latitude.*

This Table contains a correction to be subtracted from the latitude to adapt it to the spheroidal figure of the earth. The latitude so reduced is used in computing the longitude from an observed occultation. The correction from this Table is also used to adapt the altitudes used in clearing the lunar distance to the true figure of the earth. See page 261.

TABLE XIV.—*Augmentation of the Moon's Semi-diameter.*

The semi-diameter of the moon, as given in the Nautical Almanac, is her apparent semi-diameter when she is in the horizon; but as her altitude increases, she approaches nearer to the observer, till, when in the zenith, she is nearer to him by the earth's semi-diameter. Her apparent semi-diameter will, therefore, gradually increase as she attains a greater altitude, and this augmentation is found in Table XIV. below the nearest semi-diameter to that taken from the Nautical Almanac, and opposite to the given altitude.

EXAMPLE.—If the moon's semi-diameter, taken from the Nautical Almanac, be 15′ 50″, what will her apparent semi-diameter be at the altitude of 56°?

Opposite 57°, the nearest altitude in the Table to 56°, and below 15′ 50″, stands the augmentation of the moon's semi-diameter	13·5″
Given horizontal semi-diameter.....	15 50
Required semi-diameter	16 3·5

TABLE XV.—*Contraction of the Semi-diameters of the Sun and Moon from Refraction.*

As the nearer the horizon any celestial object is, the greater is the refraction to which the rays of light from it are subjected, therefore the refraction corresponding to the centre of the sun or moon, will be greater than that corresponding to any point in the disk above the centre, and less than that at any point below it. Every diameter, therefore, except that which is parallel to the horizon, will suffer in apparent contraction, the vertical diameter being contracted most; and when great nicety is required in computation, the effect of this contraction ought not to be neglected.

Let it be required to find the apparent vertical semi-diameter of the sun or moon at the altitude of 10°, the horizontal semi-diameter being 15′ 55″?

Here the inclination of the required semi-diameter to the horizon is 90°, therefore opposite 90° of inclination, and below 10° of altitude, is found 8″ the contraction of the semi-diameter from the effect of refraction, therefore the apparent vertical semi-diameter is 15′ 55″ − 8″ = 15′ 47″.

If the semi-diameter whose inclination to the horizon is 36° had been required, it would have been found in the same way to be $15' 55'' - 3'' = 15' 52''$; and if in measuring a lunar distance, the semi-diameter of either object should be inclined to the horizon, it ought to be corrected for the effect of contraction before it is applied to the distances.

The inclination may easily be computed from the apparent zenith distances of the objects and their apparent distance, which form the three sides of a spherical triangle. The difference between a right angle and the spherical angle at either object, is the inclination of the semi-diameter to the horizon which is to be applied to the distance, and as no great precision is requisite in the inclination, the angles may be determined with sufficient exactness by the scale.—(See the use of the Mariner's Scale.)

Table XVI.—Contains the sun's semi-diameter for every tenth day of each month. In computing from delicate observations, the semi-diameter may be taken from this Table if the observer should not have a Nautical Almanac.

Table XVII.—*Correction of the Moon's Meridian Passage.*

This Table is used to deduce the instant at which the moon passes any given meridian, from the time at which she passes the meridian of Greenwich, as given in the Nautical Almanac. —In the Table, below the daily change in the time of her transit, and opposite the given longitude is the correction, to be added to the time of her meridian passage at Greenwich in west longitude, and subtracted in east, for the required time. And if the longitude in time be applied to this time by addition or subtraction, according as it is west or east, the corresponding time at Greenwich will be obtained.

Example.—Required the time at which the moon passes the meridian of 80° W. on September 9th, 1823?

Per Naut. Alm. (see Table XXXII.) the moon passes the meridian of Greenwich on the given day at $3^h\,40^m$, and on the following day at $4^m\,32^s$, whence the daily diff. of her meridian passage or transit is 52^m; below the nearest minute to which and opposite long. 80° is 11^m, which added to $3^h\,40^m$ gives $3^h\,51^m$ the required time; and if $5^h\,20^m$ the long. in time were added to this time, the sum $9^h\,11^m$ would be the instant of Greenwich time at which the moon passed the given meridian.

Table XVIII.—*To compute the Equation of equal Altitudes.*

Opposite the elapsed time between equal altitudes of the sun as observed on the same day, the logs. A and B are taken from this Table. Proportional parts for intermediate times may be taken out at sight.

Thus to $7^h\,11^m$ we have log. A 7·7907 and log. B. 7·5612.

$$\text{Log. A} = \log.\left(\frac{T^h}{1440}\cdot \operatorname{cosec}\frac{T^o}{2}\right), \text{ and log B} = \log.\left(\frac{T^h}{1440}\cdot \cot\frac{T^o}{2}\right)$$ see page 296

Tables XIX., XX., XXI., and XXII.

Tables XIX., XXI., and XXII. contain the declination and right ascension of the sun, and the equation of time, for app. noon of every day, Greenwich time, in the years 1822, 1823, 1824, and 1825; and with the aid of Table XX. these elements may be found for the noon of any day till 1886.

When the declination is required at the noon of any day in years subsequent to 1825, seek the given year in Table XX., and observe which of the years 1822, 1823, 1824, and 1825, is on the same horizontal line with it; and take the declination, and the daily change of it, from Table XIX. for the given day of *that* year. Then from Part I. Table XX. opposite the declination, or the several parts of it, and under the given year, take the corresponding corrections, and their sum will be the first correction; and in Part II. of the same Table, opposite the nearest minute of declination, and under the given year, will be found the second correction. If the declination from Table XIX. is increasing, *add*, but, if decreasing, *subtract* the first correction from it, and in all cases subtract the second correction, and the result will be the required declination.

The equation of time, and its daily change, are taken in the same way from Table XXII. for the years 1822, 1823, 1824, or 1825, which is on the same line with the given year in Table XX.; and in the first part of that Table, (considering the seconds of arc in the Table as seconds of time, in daily change,) below the given year will be found the corresponding correction; which added to the equation from Table XXII. when the equation is increasing,

but subtracted when it is decreasing, will give the equation at the noon of the given day. The nearest ten seconds in the Table to the daily difference may be taken to find the correction.

The sun's right ascension being taken from Table XXI. for the given day of the year corresponding to the given one in the column on the left of Table XX., multiply 7·3″ by the periods of 4 years, above the given year, add the result to the right ascension from Table XXI., and the sum will be the right ascension at the noon of the given day.

Example 1st.—Required the sun's declination, August 14, 1867?

1867 is on the same line with 1823, we therefore take the declination and its daily change for August 14th, 1823, and find it 14° 33′ 48″ N.—18′ 31″.

Daily change of Declination.	10′ 0″	....Correction below 1867	3′ 23″	Table XX. Part I.
	8 0	.....	2 42	
	31	.....	10	
	18 31	....Correction, Part I.....	— 6 15	sum
⊙'s declination, Aug. 14th, 1823.....			14 33 48	
			14 27 33	
Opposite 19′ the nearest minute to 18′ 31″ and below the given year in Part II.			— 13	Cor. ..... Part II.
		Required declination	14 27 20	

Example 2d.—Required the sun's right ascension, May 8th, 1854?

1854 is in the same line with 1822; and the right ascension for May 8th, 1822, is $2^h\ 59^m\ 14^s$. Now above 1854, in Table XX., is 8, the periods of 4 years. Hence $7·3″ + 8 = 58·4″$, the correction of the right ascension; therefore $2^h\ 59^m\ 14^s + 58·4″ = 3^h\ 0^m\ 12·4^s$ is the required right ascension.

Example 3d.—Required the equation of time for December 28th, 1876?

1876 being in the horizontal line, in Table XX., with 1824, we take the equation of time from Table XXII. for December 28th, 1825, and find it to be $2^m\ 1^s + 29^s$.

To daily change 30″, the nearest to 29″ in Part I. Table XX., below 1876 stands 12″ which we take as 12^s, the correction +.

Equation of time, December 28th, 1824		2″ 1
Correction.....		+ 12
Ditto, December 28th, 1876 ....1876.		2 13

The elements corrected in the above manner will be exact enough for use at sea, as they will in all cases be within a few seconds of the truth; but persons having the Nautical Almanac for the given year need not of course apply to these Tables, which however may be of the utmost importance to persons who may be in situations where a Nautical Almanac cannot be had.

If the data from these Tables, or from the Nautical Almanac, are required for a given Greenwich *time of day* they may readily be found with the aid of Table XXX., as explained in problem XII., page 222.

From 1834 the *hourly* change of these elements will be given from day to day in the Nautical Almanac. This multiplied by the hours and decimals of an hour in the Greenwich date will give the correction for Greenwich time. Thus if the hourly change be 48·3″, and the Greenwich time be $18^h\ 24^m = 18·4^h$, the correction is $48·3″ \times 18·4 = 789·7″ = 13′\ 9·7″$ to be added if increasing and subtracted if decreasing.

Table XXIII.—*Mean Right Ascension and Declination of the principal fixed Stars, &c.*

The mean right ascension and declination of the stars in this catalogue for years subsequent to 1820, are determined by multiplying the annual variation by the difference between 1820 and the given year, and applying the product to the right ascension and declination given in the Table by addition or subtraction according as the sign of the variation is + or −. Thus if it were required to find the right ascension and declination of α. Leo, or Regulus for July, 1856, or about 36 5 years after the beginning of 1820, we have by Table XXIII.

R. A. Regulus, January 1st, 1820	$9^h\ 58^m\ 47^s$
Annual variation $3{\cdot}21^s \times 36{\cdot}5 = \ldots\ldots$	+ 1 57
R. A. July, 1856	10 0 44
Declination, Regulus, January 1st, 1820.	12° 50′ 36″ N
Annual variation, $17{\cdot}23'' \times 36{\cdot}5 = \ldots\ldots$	— 10 29
Declin. July, 1856	12 40 7

The stars marked in capitals are those from which the moon's distance is given in the Nautical Almanac for the purpose of finding the longitude.

TABLE XXIV.—*Correction of ☽'s apparent Altitude.*

This Table contains the difference of the moon's refraction and parallax in altitude, or the *correction of altitude*, to be added to the apparent, to obtain the true altitude.

The moon's apparent altitude, or the nearest less one in the Table being sought in the proper column; on the same line, below the minutes of parallax, will be found the first part of the correction; and in the column on the left the seconds of correction corresponding to the difference between the altitude before taken and the given one; and in the column of parts for seconds of parallax will be found the parts of correction for every ten seconds, and also for every single second of parallax; and the sum of these four parts is the whole correction.

EXAMPLE 1st.—The moon's apparent altitude is 40° 35′, and her horizontal parallax 58′ 37″, required the correction of her altitude?

Opposite 40° 30′ of ☽'s alt. and below 58′ is	42′ 54″	
5 of alt. in the column on the left	3	parts.
30″ of parallax in "parts for seconds of parallax" ..	22	do.
7	5	do.
Correction	43 24	

EXAMPLE 2d.—Given the moon's apparent altitude 58° 40′, and horizontal parallax 59′ 23″ to find the correction of her altitude.

58° 40′ below 59′	29′ 58″	
0 of alt. in the left column	8	parts.
20″ parallax in "parts for seconds of parallax"	10	
3	2	
Correction	30 18	

TABLE XXV.—*Auxiliary Arcs used in clearing the Lunar Distance.*

If h be the apparent, and H the true altitude of the moon, h' the apparent and H' the true altitude of the sun, then the arc taken from this Table is that whose cosine is $= \frac{\cos H \cos H'}{2 \cos h \cos h'}$.

This Table is arranged and used in the same manner as Table XXIV., requiring only an additional correction for the altitude of the sun or a star, which correction is found in the column on the right of the page. To the minutes and seconds taken from the Table, 60° which stands at the top of each column is to be prefixed. When a planet is one of the objects, instead of the correction for the sun or star's altitude, the correction is to be taken from Table XXVII.

Tables XXIV. and XXV. being used jointly in the practical methods which we have selected for clearing the lunar distance from the effects of parallax and refraction, they are printed on alternate pages, that the same degrees on each Table may appear at one opening of the book.

EXAMPLE.—The moon's app. alt. is 67° 14′, the sun's 30° 2′, and the moon's horizontal parallax 54′ 55″, required the auxiliary arc?

At ☽'s alt. 67° 10′ and below 54′ is.....	60°	27′	37″
at 4′ of alt.....			1
50 seconds of ☽'s parallax			27
5 ditto			3
To ☉'s alt. 36° corresponds.....			3
Required arc.....	60	28	11 sum.

TABLE XXVI.—*Parallax of the Planets in Altitude.*

Opposite the given altitude of the planet, and below its horizontal parallax, is its parallax in altitude, which deducted from the refraction corresponding to the same altitude, Table IX. gives the planet's correction of altitude.

TABLE XXVII.—*Corrections to be added to the Arcs from Table XXV. in clearing the Distance between the Moon and a Planet.*

When the true distance of the moon from a planet is to be computed, the corrections from this Table are to be used instead of those for the altitude of ☉ or ☼ in the column on the right of Table XXV. This Table is similar in its form, and used exactly as Table XXVI.

TABLE XXVIII.—*Decimal Versed and Suversed Sines.*

The first figure in each number of this Table is the second decimal figure in the natural versed or suversed sine of the arc to which the number belongs. The Table is used in *clearing the distance* of the moon from the sun or a star; and as the true distance never differs much more than a degree from the apparent one, the figures which are omitted can never be wanted to discriminate to what *degree* the versed sine of the true distance belongs, when the apparent distance is known.

To take from the Table the versed sine of a given arc. If the degrees are at the top of the Table, the minutes will be found in the column on the left; but if the degrees are at the bottom, the minutes will be found in the column on the right, and the versed sine for the *degrees* and *minutes* will be found in the column "versed" below or above the given degree, and opposite the given minute; and the parts to be added for the seconds in the given arc are found in the column of "Parts for″" belonging to the given degree, opposite the given seconds, in the column on the left. This column is marked at the top with ′, and also both at the top and bottom with [vers] to show that whether the degrees are at the top or bottom of the Table the seconds are to be sought in the column on the left.

EXAMPLE 1st.—Required the versed to 63° 12′ 43″?

Below 63° in column "versed", and opposite 12′ in the left-hand column stands	49122
Below 63° in column "Parts for″" and opposite 43 in the left-hand column stands	187
Required versed	49309

EXAMPLE 2d.—Required the versed to 138° 50′ 37″?

Above 138° in column "versed", and opposite 50′ in the right-hand column stands	52798
Above 138° in column "Parts for″", and opposite 37 in the column on the left stands.....	120
Required versed	52918

To find the Arc corresponding to a given Versed Sine, when the Arc is known to within about a Degree.

In the column versed corresponding to the given degree, or to one of the degrees immediately adjoining to it, find the versed sine next less than the given one, and the corresponding degrees and minutes will be those of the required arc. Subtract this versed from the given one, and opposite the remainder taken in the "Parts for″" belonging to the degree already taken out, will be found the seconds of the required arc *in the column on the left*.

EXAMPLE 1st.—The versed sine of an arc known to be within about a degree of 54° is 09237, required the arc?

In the columns of versed adjacent to 54° we soon find the versed next less than 09237 is 09160, the versed sine of 53° 47′.

Given versed sine	09237
Versed 53° 47′	09160
Difference	77

To this difference in "Parts for″" corresponds 20″ *in the column on the left*, whence the required arc is 53° 47′ 20″.

Example 2d.—Required the arc, nearly 113°, which corresponds to versed 98341?

The versed sine next less than 98341 in the columns adjoining to 113° is 98216, the versed of 113° 28′, and the difference between this versed sine and the given one is 125, which found in the column of "Parts for″" belonging to 113° corresponds to 28″ *in the column on the left*, whence the required arc is 113° 28′ 28″.

To find the Suversed Sine of a given Arc.

In taking out the suversed sines *the arc is always conceived to be increased by one minute*, and the parts for seconds are found opposite the given seconds of arc, *taken in the column on the right;* by this means the parts for seconds are made additive in the suversed as well as in the versed sines.

Example 1st.—Required the suversed sine of 18° 36′ 15″?

Increasing the arc by one minute we have to 18° at the top, and 37′ on the left, suversed 47676, and in the column of "Parts for″" opposite 15″ *on the right*, we have 70 for the parts for seconds, hence 47676 + 70 = 47746 the required suversed sine.

Example 2d.—Required the suversed sine of 126° 19′ 34″?

Increasing the arc by one minute we have to 126° at the bottom and 20′ on the right, 07518; and in the column of "Parts for″" opposite 34″ *in the column on the right*, we have 102 for the parts for seconds, whence 07518 + 102 = 07620 is the required suversed sine.

When the Versed Sine of an Arc exceeding 180° *is required, reject* 180° *from the Arc and seek the Suversed Sine of the Remainder.*

In taking the sum of several versed and suversed sines, the tens are always to be rejected from the sum of the left-hand figures, and it will be found convenient to add the sum of the parts for seconds to the sum of those for degrees and minutes, instead of making a separate addition for the parts for seconds in each arc.

					"Parts for″"
Thus.... vers.	48°	10′	46″	.....33034....	168
vers.	138	24	19	.....47798....	60
suvers.	73	52	26	.....77594....	158
suvers.	167	4	52	.....25304....	8
Sum of parts for seconds				394....	
Total sum				84124	

Table XXIX.—*Proportional Logarithms.*

These logarithms are of very extensive use in making proportions among hours, minutes, and seconds of time, or degrees, minutes, and seconds of arc. If a = the seconds in 3 hours of time, or 3° of arc, and b = the seconds in any time or arc not exceeding a, then log. a − log. b is the proportional logarithm of the arc b.

Proportions among sexagesimals are performed as in common logarithms, by subtracting the proportional logarithm of the first term from the sum of those of the second and third, and the remainder is the proportional logarithm of the fourth term.

It may be observed too, that the minutes in the Table may be considered as degrees, and the seconds as minutes, and therefore though the Table extends to only 3° or 3^h; the proportion between much greater arcs may be readily deduced from it.

Example.—If the altitude of the sun increase 38′ 15″ in 4^m 20^s, what will it increase in 1^m 39^s?

The proportion is, as 4^m 20^s is to 38′ 15″, so is 1^m 39^s to 14′ 34″; or by proportional logarithms .....

4^m 20^s	prop. log.	1·6185
38′ 15″	ditto	6726
1^m 39^s	ditto	2·0378
		2·7104
Answer 14′ 34″	ditto	1·0919

When the first term of the proportion is 3^h or 3°, its proportional logarithm being 0, the proportional logarithm of the fourth term is obtained by taking the sum of the proportional logarithms of the second and third; and when the second term is 3^h or 3°, the proportional logarithm of the fourth is obtained by subtracting the proportional logarithm of the first term from that of the third, and it was to facilitate the computing of such proportions that the Table was originally formed.

Note.—From 1834 between every two successive lunar distances in the Nautical Almanac, the proportional logarithm of their difference will be inserted; and this proportional logarithm being subtracted from that of the difference between a given lunar distance and the next preceding one in the Almanac, will give the proportional logarithm of the time to be added to that corresponding to the said next preceding distance to find the Greenwich time.

As an example we may take that at the bottom of page 273, where the proportional logarithm ·2987 will then be found between the distances 66° 5′ 2″ and 67° 35′ 31″. Hence the computation will stand thus:

True dist. 66° 37′ 0″	diff. 0° 31′ 58″	prop. log.	·7506
Next preceding dist. at 9^h 66 5 2		subtract	·2987
	1^h 3^m 35^s	prop. log.	·4519
Time of preceding dist.	9		
Greenwich Time	10 3 35		

If the proportional logarithms of the differences of distance be given to *five* places of figures, reject the fifth figure, and increase the fourth by unity if the fifth is 5 or more.

TABLE XXX.—*To reduce the right Ascension, Declination, &c. of the Sun or Moon to any given Instant of Greenwich Time.*

One of the chief uses of this Table is that expressed in the title of it, but it may also be employed in many cases with advantage in taking proportional parts; for the hours and minutes in the Table may be taken as degrees and minutes, or as minutes and seconds, &c.

Its use in taking proportional parts of the *daily* variations in astronomical data is sufficiently explained at Problem XII., page 222; but as till 1833 the moon's right ascension, &c. are only given for Greenwich apparent noon and midnight, the following method of finding the corrections for intermediate times may till that period be useful.

To the logarithm from this Table corresponding to *double* the given time past noon or midnight, add the proportional logarithm of the change of the required number in the 12 hours in which the given time falls, and the sum will be the proportional logarithm of its change in the given time, which added to or subtracted from the value of the number for the noon or midnight next preceding the given instant, according as the number is increasing or decreasing, will give the value of it at the given time. If the change in 12 hours should be too great for the Table of proportional logarithms, its half, or its third part, may be taken, and the result multiplied by 2 or 3 accordingly.

This value, however, when great nicety is required, ought to be further corrected by the equation of second differences given in the Nautical Almanac.

EXAMPLE.—Required the moon's declination, September 16th, 1823, at 4^h 10^m A. M. Greenwich civil time.

☽'s declination at midnight, September 15th, (see Table XXXII.) 19° 1′ 30″ S – 1° 57′ 58″.

Double the given time 8^h 20^m, log. Table XXX			4594
Change of declination in 12 hours	1° 57′ 58″	prop. log.	1835
Correction	— 40 57	ditto	6429
	19 1 30		
Required declination	18 20 33 S.		

Use of the Table of the Equation of second differences in the Nautical Almanac for 1831 *and* 1832.

From the Nautical Almanac take four right ascensions, or declinations, two immediately preceding, and two immediately following the given instant of Greenwich time. Half the difference between the sum of the first and fourth, and that of the second and third, will be the mean second difference; with which at the top of the Table, and the given time past noon or midnight inone of the side columns, the required correction will be obtained;

additive to the right ascension corrected by even proportion, when the sum of the first and fourth is *less*, but *subtractive* when it is *greater*, than the sum of the second and third; but *always additive to the declination* as corrected by even proportion.

When the four declinations are not all of the same denomination, the correction of the declination may be found with sufficient exactness by even proportion; as under such circumstances the second differences are always too small to merit regard in nautical practice.

Tables XXXI. and XXXII.

These Tables, from the Nautical Almanac, contain the moon's right ascension, declination, semi-diameter, horizontal parallax, &c., and her distance from the sun and fixed stars used in finding the longitude for September, 1823; and all the examples in this volume relative to the moon being adapted to that month, the student is spared the necessity of purchasing a Nautical Almanac for the mere purpose of being enabled to solve the practical questions given for exercise. The data in these Tables are for the intervals adopted in the Nautical Almanac for 1833.

Table XXXIII.—*Logarithms to compute the Longitude from the difference between the Transits of the Moon's bright Limb and a Star.*

This Table is entered with the increase of the moon's right ascension (*in time*) in an hour of *mean* time. The minutes are found at the top, and the seconds and tenths of seconds in the column below. The parts for hundredths of seconds are found in the column of differences opposite the corresponding tenths of the second for which the logarithm is sought; and if the right hand figure be rejected from the differences, the remaining figures on the left will be like parts for thousandths of seconds.

Thus if the log. corresponding to $2^m\ 35{\cdot}479^s$ be required, we have 1·346928 corresponding to $2^m\ 35{\cdot}4^s$, to ·07 we have 204, and to ·009 we have 26, both to be subtracted; hence the correct log. is 1·346698.

Table XXXIV.—*Effect of a Change in the Moon's Semidiameter on the Time of its passing the Meridian.*

Below the moon's declination and opposite the seconds in the change of her semidiameter, is the required effect, in seconds of time. For tenths of seconds in the change take the part answering to the corresponding second, and remove the decimal point one place to the left.

Thus, if the moon's declination be 16° and the change of her semidiameter $4{\cdot}6^s$, we have

To 4^s, below 16°	$\cdot 29^s$
·6	·043
Ans.	·333

Table XXXV.—*Latitudes and Longitudes of Places, &c.*

On this Table we shall only observe, that great care has been taken that the information which it furnishes should be entitled to confidence, as the accuracy of such a Table constitutes its chief value.

Table XXXVI.—*Times of High Water, &c.*

The title of this Table so fully explains its object, that nothing seems wanting in the way of explanation.

THE END

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